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PENNSYLVANIA
GEOLOGICAL SURVEY
FOURTH SERIES

BULLETIN M 19

CONTRIBUTIONS TO OIL AND GAS GEOLOGY OF WESTERN PENNSYLVANIA

By

J. D. SISLER, G. H. ASHLEY, F. T. MOYER
and W. O. HICKOK, 4th

DEPARTMENT OF INTERNAL AFFAIRS
Philip H. Dewey, *Secretary*

TOPOGRAPHIC AND GEOLOGIC SURVEY
George H. Ashley, *State Geologist*

Harrisburg, Pa.
1933

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LETTER OF TRANSMITTAL

Harrisburg, February 14, 1933.

Honorable Philip H. Dewey,
Secretary, Internal Affairs,
Harrisburg, Pennsylvania.

Dear Sir:

I herewith transmit and recommend for printing the accompanying Contributions to the Geology of Oil and Gas in Western Pennsylvania.

The heart of the report is in the stratigraphic charts, prepared by Mr. Sisler. These formed one chapter in a 1200-page manuscript, submitted by Mr. Sisler as the result of a study of the oil and gas fields of western Pennsylvania during 1927 to 1929 inclusive. It had been hoped to publish this report in 1932. Allotment of funds for printing proved inadequate. A small allotment in 1933 required restricting publication to what seemed to be the most valuable part of the report.

The first chapter on the stratigraphy of the fields was completely rewritten in the light of later studies by members of the Survey, including especially George H. Chadwick and Charles R. Fettke. The chapter on statistics by Mr. Moyer attempts to bring together for the first time in one place, all the figures available. Mr. Sisler's appointment as State Geologist of West Virginia prevented his completing this chapter. Mr. Hickok's paper brings together many analyses made recently and not before available.

Respectfully submitted,

Geo. H. Ashley

State Geologist.

255114

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CONTRIBUTIONS TO OIL AND GAS GEOLOGY OF WESTERN PENNSYLVANIA

STRATIGRAPHY OF THE OIL AND GAS FIELDS OF PENNSYLVANIA

By Geo. H. Ashley and J. D. Sisler

INTRODUCTION

The productive oil and gas sands of Pennsylvania occur in the Silurian, Devonian, Mississippian, and Pennsylvanian systems. The Silurian is underlain by the Ordovician, Canadian, and Cambrian systems which are not known to contain oil and gas in commercial quantity in this State. The Pennsylvanian is overlain in southwestern Pennsylvania by the Permian system which is barren of oil and gas. The Silurian system contains the Medina (Tuscarora) sand, which lies deep in western Pennsylvania and has yielded very little oil and gas in this State, though there are abundant producing wells in this sand in adjoining States. The chief production of the central part of the oil and gas fields comes from the Devonian. The Pennsylvanian, Missisippian and Upper Devonian rocks are prolific sources of oil and gas in southwestern Pennsylvania.

The rocks below the Medina and those above the Pittsburgh coal are not discussed in this chapter because they are apparently unimportant as oil and gas-producing horizons. A bulletin, G-1, Syllabus of Pennsylvania Geology and Mineral Resources, recently issued, describes briefly the stratigraphy of the rocks in western Pennsylvania, and the information will not be repeated in this bulletin. The geologic time scale (Plate I) from the Syllabus will serve to illustrate the position that the various oil and gas-bearing rocks occupy in the succession of formations in Pennsylvania.

Oil and gas production to the present has come from groups: 42, 52, 53, 57-62, 74-76, 77, 78.

As the oil-and gas-bearing sandstones have been given many names which seldom correspond with the geologic names of the same beds, the correspondence of the geologic names with the drillers names is shown in the following table. The correlations indicated below the Big Injun or Burgoon are all tentative and subject to change on further study.

Correlation table of principal oil and gas sands and marker horizons of Pennsylvania.

Systems	Series	Groups	Geologic names of outcropping beds	Driller's names (Correlation below Big Injun and Berea tentative) First name most widely used.	Intervals		
					South-western	Central	Northern
PENNSYLVANIAN	Pittsburgh	Monongahela	Pittsburgh coal	Pittsburgh coal	0		
		Conemaugh	Morgantown sandstone	Murphy sand	140		
			Saltsburg sandstone	Little Dunkard, Cow Run sand	310	700	
			Mahoning sandstone	Big Dunkard, Hurryup sand	515	530	
		Allegheny	Upper Freeport coal	Upper Freeport or Connellsville coal	625	430	
			Freeport sandstone	Upper Gas or Second Cow Run sand	670	390	
			Kittanning sandstone	Middle Gas sand			
			Vanport limestone	Ferriferous limestone		200	
			Clarion sandstone	Lower Gas sand	825	190	
	Pottsville	Beaver River	Homewood sandstone	First Salt sand	915	130	
			Connoquenessing sandstone	Second Salt sand	1000	60	530
			Sharon (Olean) sandstone	Third Salt sand, Maxton sand			430
MISSISSIPPIAN	Chester	Mauch Chunk	Greenbriar limestone	Little lime, Salvation sand	1100		
			Red shale	Pencil cave	1120		
	Meremec	Ste. Genevieve	Loyalhanna limestone	Big Lime, Mountain limestone	1150		
	Waverly (Pocono)	Burgoon	Burgoon sandstone	Big Injun or Mountain sand	1200	0	380
			Shenango sandstone				
		Cuyahoga	Meadville (Patton)	Red shale	1550	300	
			Sharpsville sandstone	Squaw sand	1600		290
			Sunbury (Orangeville)	Papoose sand	1715		
		Berea	Berea (Corry) sandstone	Berea and Murrysville, Butler-thirty-foot, Second Gas.	1775	550	150
DEVONIAN	Upper Devonian	"Catskill"	Cussewago sandstone	Hundred-foot, Fifty-foot, and Gantz First sand of Venango County	1875	750	0
			Riceville shale	Thirty-foot, Nineveh thirty-foot	1980	850	
			Woodcock sandstone	Snee, Blue Monday, Boulder, Hickory	2045	925	140
			Saegertown shale	Gordon stray, Third stray, Campbell Run sand, Second sand Venango County	2080 2150	1040	280
			Miller or Salamanca sandstone	Gordon, Third sand of Venango County	2200	1100	380
			Amity shale	Fourth sand			
			Le Boeuf or Panama sandstone	Fifth, McDonald sand	2270	1200	460
		Chemung	Chadakoin shale & flaggy sandstone	Sixth, Bayard sand	2350	1300	580
				Elizabeth sand	2475	1430	730
				Warren First sand (local)	2710	1580	850
			Girard shale	Warren Second sand (local)	2810	1700	930
				Warren Third sand	2900		1000
			Cuba sandstone (?)	Speechley stray	3000	1900	
				Speechley, Glade	3125	2010	1075
				Tiona, Clarendon	3250	2200	1200
			Northeast shale, etc.	Balltown, Gartland, Cherry Grove sands	3360	2300	1280
				Second Balltown, Chipmunk			
				Sheffield, Cooper (?) sand	3510		1570
			Shumla sandstone	First Bradford sand	3620		
			Westfield shale	Second Bradford sand	3700		
			Leona sandstone	Third Bradford, Deer Lick sand	3800	2700	1715
				Smethport, Kane, Elk groups	3900	2850	
	L. Dev.		Oriskany sandstone	Oriskany	6530	5550	5000
SILURIAN	Lower Silurian	Medina	Tuscarora sandstone	Medina sand, Clinton sand of Ohio (Est.)	8300	6750	6100

GEOLOGIC TIME SCALE

PLATE 1

Penna. Geological Survey Standard Section				First Geol. Survey of Penna.	Second Geol. Survey of Penna.	Groups and formations by number (time scale) and name (source & date) (small letters refer to members)	Group code	Maximum thickness				U.S. Geol. Survey		
Eras	Ages	Periods Systems	Epochs or Series					Western district	Central district	Northeast district	Southeast district	Series	Systems	Eras
CENOZOIC	QUATERNARY	Fifteenth or Quaternary	Recent			152 Alluvium						Recent	QUATERNARY	CENOZOIC
			Pleistocene			151 d Late Glacial c Early Glacial b Cape May N.J. 1897 a Pensauken N.J. 1894	Qw Qpw	100 80			40 30	Pleistocene		
	TERTIARY	Fourteenth or Upper Tertiary	Pliocene Miocene			149 Bryn Mawr, Pa. 1880	Tbm				50	Pliocene Miocene	TERTIARY	
		Thirteenth or Lower Tertiary	Oligocene Eocene			Not represented						Oligocene Eocene		
MESOZOIC	CRETACEOUS	Twelfth Per. or Upper Cretaceous										Up Cretaceous	CRETACEOUS	MESOZOIC
		Eleventh Per. or Lower Cretaceous			Potomac	118* Patapsco Md. 1897	Kp				740	Low Cretaceous		
	JURA-TRIAS	Tenth Per. or Jurassic				Not represented						Up Jurassic Mid Jurassic Low Jurassic	JURASSIC	
		Ninth Per. or Triassic	Upper Triassic or Newark (N.J. 1892)	Mesozoic Red SS	Triassic or Newark "New Red"	Diabase (Intrusive) 99 Brunswick, N.J. 1897 98 Lockatong, N.J. 1897 97 Stockton, N.J. 1897	Trd Trb Trl Trs				17400 3500 6100	Up Triassic	TRIASSIC	
			Mid & Low Triassic			96 91 Not represented						Mid Triassic Low Triassic		
PALEOZOIC	CARBONIFEROUS	Eighth Per. or Permian	Upp. & Mid. Permian			85 83 Not represented		Eroded	Eroded	Eroded		Permian	CARBONIFEROUS	PALEOZOIC
			Dunkard (Pa. 1891)	XIII XIII Up. Bar.	XVI Greene Co. Measures XV Washington Co. group	82 Greene, Pa. 1876 81 Washington, Pa. 1876	Cg Cw	750 400						
		Seventh Per. or Pennsylvanian	Pittsburgh (Pa. 1839)	XIII Up. C.M. XIII Low. Bar. XIII Low. C.M.	XIV Monongahela River CM XIV Pittsburgh (L. Bar.) XIII Allegheny River CM	79 Monongahela, Pa. 1840 78 Conemaugh, Pa. 1879 77 Allegheny, Pa. 1840	Cm Ccm Ca	400 650 370	500 300	500 1550 350		Pennsylvanian		
			Pottsville (Pa. 1877)	XII Seral Millstone Grit	XII Pottsville	76 71 Pottsville, Pa. 1877	Cpv	400	250	1400				
		Sixth Per. or Mississippian	Chester (Ill. 1857)	XI Umbral	XI Mauch Chunk	67 Mauch Chunk, Pa. 1877	Cmc	150	1000	2200		Mississippian		
			Meramec			66 Ste Genevieve (Loyalhanna) 1857 1935 65 63 Not represented	Cl	60	40	0				
			Waverly O. 1838	X Vespertine	X Pocono	61 Pocono, Pa. 1858 c Burgoon, Pa. 1908 b Cuyahoga, O. 1870 a Berea, O. 1870	Cpo	750	1400	1100				
	DEVONIAN	Fifth Per. or Devonian	Upper Devonian	IX Ponent	IX Catskill (Old Red SS) VIII Chemung Portage Genesee	59 Catskill, N.Y. 1842 58 Chemung, N.Y. 1838 57 Portage, N.Y. 1840 56 Genesee, N.Y. 1841	Dck Dch Dp	2000 drilled	2500 3300 1600	7000		Up Devonian	DEVONIAN	
			Middle Devonian	VIII Cadent	VIII Hamilton Marcellus Corniferous	55 Hamilton, N.Y. 1839 54 Marcellus, N.Y. 1839 53 Onondaga, N.Y. 1839	Dhm	2750	? 1700 150	200 2375 600		Mid Devonian		
			Lower Devonian	VII Meridian VI Premeridian	VII Oriskany SS VI Low Helderberg ls	52 Oriskany, N.Y. 1838 51 Helderberg, N.Y. 1838	Do Dhb		50 400 150	300 600		Low Devonian		
	SILURO	Fourth Per. or Silurian	Salina (N.Y. 1864) "Cayuga"	V Scalent	V c Salina sh.	49 Tonoloway, Md. 1912 48 Wills Creek, Md. 1912 47 Bloomsburg, Pa. 1885	S3	Est. 2600	600 400 450	1200	Eroded		SILURIAN	
			Niagara (N.Y. 1842)		V b Niagara V a Clinton	46 Lockport, N.Y. 1838 45 Rochester, N.Y. 1838 44 Clinton, N.Y. 1841	S2		1400 1200	1000				
			Medina (N.Y. 1842)	IV Levant	IV a "Oneida" b Medina	43 Tuscarora, Pa. 1897 42 Juniata, Pa. 1857 41 Oswego, N.Y. 1841	S1		600 650 800	1200 0 0				
	CAMBRO-ORDOVICIAN	Third Per. or Ordovician	Cincinnati (O. 1853)	III Matinal	III b Hudson River sh. III a Utica sh.	39 Pulaski, N.Y. 1840 38 Frankfort, N.Y. 1840 37 Utica, N.Y. 1842 Reedsville Martinsburg			1500	6000	7000	Up Ordovician (Cincinnatian)	ORDOVICIAN	
			Mohawk (N.Y. 1840)		II c Trenton ls.	36 Trenton, N.Y. 1837 35 Black River, N.Y. 1842 34 Lowville, N.Y. 1855, "Birdseye" Chambersburg	Ot Obr Ol		750 40 180	500 100		Mid Ordovician (Mohawkian)		
			Blount (Tenn.)			33 31 Not represented					750			
		Second Per. or Canadian	Chazy (N.Y. 1842)		II b Chazy ls.	29 Valcour, N.Y. 1906 28 Stones River, Tenn. 1893 27 Not represented	Osr		245 250		1050	Low Ordovician		
			Beekmantown (N.Y. 1839)		II a Calciferous ss.	26 Bellefonte, Pa. 1911 25 Nittany, Pa. 1911 24 Tribes Hill, N.Y. 1910 Shenandoah or Kittatinny	Ob		1900 1600 700	1500	2300			
			Ozark (Mo. 1891)	II Auroral		23 Chepultepec, Ala. 22 Copper Ridge, Tenn. 21 Conococheague, Pa. 1905	Oc		250 250 1750		1550			
		First Per. or Cambrian	St Croix (Wis. 1872)			19 Elbrook (Pa. 1903) b Warrior 18 a Pleasant Hill	Ce Cph		1150	1500	3000	St. Croixian	CAMBRIAN	
			Acadia (N.B. 1887)			14 Rome, Ga. 1890 13 "Waynesboro" 1909	Cw		300		1000	Acadian		
			Waucoba (Calif.)	I Primal	Potsdam ss + Chickies ss White quartzite	13 Tomstown, Pa. 1901 c Ledger b Kinzers a Vintage 12 Harpers, Pa. 1894 11 Chickies, Pa. 1883	Ct Ch Cc		Not exposed	300	1600 3350 1500	Waucoban		
PROTEROZOIC	ALGONKIAN	Keweenawan	Glenarm	Primal Older Slates	Huronian system	(Igneous) (Metamorphic) Pegmatites Peach Bottom slate Woodstock gr. Peters Creek schist Granite, gabbro Wissahickon schist Volcanics Cockeysville marble Setters group	pg pb wk pc g ws vol cy st				1000 2000 10000 400 1000	Keweenawan Huronian	ALGONKIAN	PROTEROZOIC
		Animikian												
		Huronian												
	ARCHEAN	Laurentian		Primal Crystalline Schists	Archean	Hartley gn. Franklin marble Baltimore gneiss	hgn fr bm						ARCHEAN	

PENNSYLVANIAN SYSTEM

PITTSBURGH SERIES

The readily identified Pittsburgh coal within its area of outcrop is, because of its thickness and regularity, an ideal horizon from which practically all measurements of interval to the rocks below have been made. It is practically a continuous bed within the area of its outcrop in Pennsylvania, though not in West Virginia.

Conemaugh group. Three sandstones of the Conemaugh group have yielded small quantities of oil and gas in the southwestern corner of the State where they lie more than 1,500 feet deep. These are the Morgantown, Saltsburg, and Mahoning sandstones. The Conemaugh group thickens from about 500 feet in the Pittsburgh area to about 900 feet in Somerset County.

Allegheny group. The Upper Freeport coal, which is very persistent, though usually not a thick bed, has been used as a marker in areas where it is present and the Pittsburgh coal is lacking. The Vanport limestone near the base of the group has been used in a similar manner. Oil and gas have been found in this group in sands correlated as the Freeport, Kittanning, and Clarion sandstones.

Beaver River group. Lower and Middle Pottsville rocks are absent in western Pennsylvania, that area having been a land surface undergoing erosion while rocks of those ages were being deposited in eastern Pennsylvania and southward. This group contains four sandstones, the Homewood, Upper and Lower Connoquenessing, and Sharon, all of which locally yield oil and gas. The Sharon or Olean is lacking except in the extreme northwest counties of the State. The sandstones vary from massive to shaly and locally may be entirely replaced by shale as is true of all the higher sandstones. The thickness varies from 60 to 250 feet.

MISSISSIPPIAN SYSTEM

Mauch Chunk series. The Mauch Chunk series (Chester series of the Mississippi Valley) consists of red shales and sandstones several thousand feet thick in eastern Pennsylvania. Having been subjected to erosion in the northwestern part of the State during early and middle Pottsville time, the series is entirely lacking in most of that area. The western limit follows approximately a line running east a little south of Pittsburgh, through Saltsburg, Indiana, and the southeast corner of Jefferson County, and thence northward. In southwestern Pennsylvania the thin Greenbriar limestone is near the base of the series. Little or no oil or gas comes from this series. The Mauch Chunk is 180 feet think on the Allegheny Front, 30-140 feet thick in the Latrobe area, and 250 feet thick in the Connellsville area.

Loyalhanna limestone. This limestone, which is an excellent horizon marker where it occurs, is now known not to be a part of the Pocono, but to correlate with the Ste. Genevieve limestone of upper-Middle Mississippian age in the Mississippi Valley. It is confined to the south half of the oil and gas fields of Pennsylvania. It varies from a sandy limestone to a limy sandstone and locally is oölitic. The limestone is irregular and not over 60 feet thick, but persistent within its area of outcrop.

POCONO SERIES

Burgoon group. The Pocono series of central Pennsylvania is about 1,100 feet thick and consists of three groups, the Burgoon sandstone at the top, about 300 feet thick, the Cuyahoga group in the middle, and at the base of the series a sandstone correlated with the Berea sandstone of northwestern Pennsylvania. In the Foxburg region the Burgoon sandstone is 300 to 320 feet thick. Northward the erosion to which that area was subjected in pre-Pottsville time cut down the thickness of the Burgoon so that at Tionesta it has all been removed. Farther north erosion has even reduced the thickness of the Cuyahoga formation until in southern New York, the Pottsville sandstone lies directly on Upper Devonian rocks. The Burgoon is usually spoken of as though it were a single massive sandstone. In outcrop, however, it is dominantly a sandy member nowhere evenly bedded but it does contain some massive sandstone beds and many layers 4 to 6 inches thick. In places there are shale lenses up to 60 feet thick, and occasional streaks of carbonaceous matter which locally in central or eastern Pennsylvania may be coal beds. This sandstone is generally coarse, not very clean, and often cross-bedded.

Cuyahoga group. The Cuyahoga group in central Pennsylvania consists of the Patton red shale (50 feet thick) at the top, the Riddlesburg shale (75 to 95 feet thick) at from 495 to 670 feet below the top of the Burgoon, and the Broad Ford sandstone (30 to 150 feet thick), its top being 270 to 510 feet above the base of the group. In the northwest corner of the State this group consists of the Meadville shale and limestone member 65 feet thick, the Sharpsville sandstone and limestone member 70 feet thick, the Sunbury (Orangeville) shale member 75 feet thick. The Sharpsville sandstone or flags are correlated with the Squaw sand of the drillers. The Papoose sand is thought to be a sandstone in the Sunbury shale.

Berea sandstone. This sandstone forms the base of the Pocono in Pennsylvania, though in Ohio, according to George H. Chadwick, the Bedford, Cleveland, Olmstead, and Huron shales wedge in from the west below the Berea, but do not extend into Pennsylvania. The Berea is an even-grained sandstone up to 175 feet thick in Ohio, but it thins eastward. It is correlated in Pennsylvania with the Corry sandstone at Corry 20 feet thick, and is thought to be only a foot or two thick in the Warren region. The stratigraphic relation of the Berea sandstone with the First, Second, and Third oil sands of Venango County has long been a matter of study. I. C. White in Report Q-4, of the Second Geological Survey, identified the Shenango sandstone at the base of the Burgoon with a sandstone being quarried near Titusville at 305 feet above the First sand in the Drake well. As the interval from the Shenango sandstone to the Corry at Kerris Mill a few miles north is only 210 feet, White concluded that the First sand was not the same as the Corry, but lies 100 feet or more below, which according to the general section was made to correspond with either the Cussewago sandstone or the "Venango upper sandstone," later called by Chadwick the Woodcock sandstone. Later Charles Butts, in a section made down the Allegheny River, and described in the Topographic and Geologic Survey Commission's report for 1906-1908, correlated the Berea with the First oil sand. J. D. Sisler's studies lead him to agree with I. C. White and to correlate the First sand with the top of the Hundred-foot sand at a short distance below the Berea. It will probably require detailed areal mapping to settle the matter with certainty. In this report the Berea is correlated with sands above the First sand or Hundred-foot sand.

Age. The age of the Pocono and the position of the line between the Mississippian and Devonian presents many difficulties. The three major elements, Burgoon sandstone at the top, Cuyahoga sandstone and shale in the middle and Berea sandstone at the base, appear to persist all through western Pennsylvania, ranging in thickness from 1,140 feet in the Broad Top region, 970 feet in Allegheny Mountain west of Altoona, 1,085 feet or less near Johnstown, 920 feet near Latrobe, 1,100 feet near Uniontown, 700 to 900 feet near Foxburg, 750 feet in Washington County, to 500 to 700 feet in eastern Ohio.

Unfortunately the evidence for the age of the series is conflicting. In northeast Ohio and northwest Pennsylvania the Berea sandstone is highly fossiliferous, and on the basis of these fossils the sandstones have been definitely correlated with the Lower Mississippian (Kinderhook) of the Mississippi Valley.* The Pocono along Chestnut Ridge in Fayette County, has been described as only 240 feet thick and underlain by sandstones and shales containing typical Chemung fossils to within 12 feet of the base of the supposed Pocono. This occurrence has usually been described as an example of unconformity, on the assumption that the middle and lower Pocono as well as the "Catskill" are lacking at this point. But a study of the sections and drill records of adjacent areas leads the writer to believe that the section is normal at this point, and the Chemung fauna occurs at the top of the Cuyahoga group. Fossils occur at several horizons in the Pocono on the Allegheny Front. They are said to be inconclusive but at the lower horizons to point toward Devonian rather than Carboniferous age. Chadwick has suggested recently that when traced eastward in northern Pennsylvania the lower Pocono appears to grade into strata of recognized Devonian age.

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*Prosser, Chas. S., Geol. Survey of Ohio, Bull. 15, Devonian and Mississippian. p. 526.

The problem is simply stated here in order that too much weight be not given to the suggested correlations of the tables. Moreover the remarkable persistence of the Berea sandstone through eastern Ohio, and across western Pennsylvania to the Broad Top region or beyond*, suggests its correlation with the persistent Hundred-foot sand of the drillers rather than with the much more irregular and less persistent "Berea" or Murrysville sands of the drillers.

DEVONIAN SYSTEM

The Devonian rocks in Pennsylvania range in thickness from 8,000 to 10,000 feet in eastern Pennsylvania to about 3,000 feet in the northwest corner of the State. The rocks consist of the Helderberg limestone at the base, then the Oriskany sandstone, the Onandago limestone, and toward the top a great thickness of alternating sandstones and shales. The succession of groups and their thickness in western Pennsylvania is shown in the accompanying table.

There is still some question as to whether the Catskill should be treated as a group or as a phase of the Upper Devonian. The Upper Devonian is red at the top. These red beds do not form a uniform band at the top of the system but are found to include lower and lower strata at the east, so that on the Delaware River not only the Chemung, but also the Portage beds are red and in the past have been called Catskill.

Oil and gas have been obtained in the Devonian from the Catskill, Chemung, Onondaga and Oriskany groups. Each of these groups has been subdivided into many named sandstone, shale, and limestone members, some only a few feet thick, others several hundred feet. The oil and gas sands consist of persistent sandstone members, or less persistent beds or lenses in the intermediate shaly members. Detailed study of these rocks on the outcrop in New York and northern Pennsylvania is in progress by George H. Chadwick, and will be the subject of one of this series of oil and gas papers. The discussion here is drawn largely from the work already done by Mr. Chadwick. Tracing along the outcrop shows that some of these relatively thin sandstones are remarkably persistent, while others are limited in extent, sometimes to areas only a few miles across. It seems that

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*Reger, David B., Bull. Geol. Soc. of Amer., vol. 38, pp. 406-407.

Table of thickness of rock formations (G. H. Ashley) using (in part) interpretations by Geo. H. Chadwick, measured from base of Pocono

Strati-graphic groups	McDonald well (Geary) Washington County		Ohio (General) Prosser		Naylor well (U. N. G. Co. No. 3508) Crawford County		Erie and Erie County		Tidioute well Fid. Pet. Corp. No. 1 Warren County		Kane well (U. N. G. Co. No. 3737) Elk County		Genesee River (Prosser and Chadwick)		Bradford well (Derrick City) McKean County		Lock Haven section (Chance) Clinton County		Altoona section (Butts) Blair County	
	Group	Total	Group	Total	Group	Total	Group	Total	Group	Total	Group	Total	Group	Total	Group	Total	Group	Total	Group	Total
1. Pocono	640	0	175	0	----	0	300	0	256	0	311+	0	----	0	----	0	1175	0	1130	0
2. "Catskill"	----	----	----	----	----	----	472	472	474	474	314	314	500	500	538	538	900	900	500	500
3. Chemung	----	----	----	----	----	----	1275	1747	2058	2522	2300	2614	1885	2385	1953	2491	2954	3854	3900	4400
4. Portage	----	----	----	----	----	----	225	2072	722	3244	1470	4084	1255	3630	1400	3891	1565	5419	1600	6000
5. Genesee	----	----	----	----	----	----	0	----	?290	3534	0	----	86	3716	150	4041	?560	5979	0	6000
6. Hamilton	----	----	----	----	----	2695+	554	2626	365	3999	760	4844	534	4250	695	4736	1131	7110	800	6800
7. Marcellus	----	4386	----	2785	115	2810	45	2671	35	4034	131	4975	40	4290	----	----	759	7869	150	6950
8. Onondaga	37	4423	110	2895	195	3005	275	2946	?134	4168	52	5027	100	4390	70	4806	0	----	50	7000
9. Oriskany	270	4693	0	----	10	3015	40	2986	15	4183	?65	5092	0	----	20	4826	0	----	300	7300
10. Helderberg	385	5078	0	----	279	3294	50	3036	----	----	----	----	0	----	0	----	370	8239	150	7450
11. U. Silurian	548+	5626	600	3495	421	3615	500	3536	1242	5425	1085	6177	682	5072	1395	6221	?500	8739	1050	8500
12. M. Silurian	----	----	400	3895	508	4123	265	3801	----	----	----	----	354	5426	----	----	1105	9844	1075	9575
13. Tuscarora	----	----	150	4045	171	4294	65	3866	191	5616	240	6417	58	5484	150	6371	695	10539	400	9975
14. Juniata	----	----	300—	4345	17+	4311	865+	4731	36+	5652	855+	7272	1020	6504	60+	6431	705	11244	850	10825
15. Oswego	----	----	0	----	----	----	----	----	----	----	----	----	83	6587	----	----	901	12145	800	11625
16. Cincinnati	----	----	250	4595	----	----	----	----	----	----	----	----	598	7185	----	----	?	----	1000	12625
17. Trenton	----	----	130	4725	----	----	----	----	----	----	----	----	954	8139	----	----	514	----	320	12945
2–7 inclusive	----	4386	----	2785	----	2810+	----	2671	----	4034	----	4975	----	4290	----	4736	----	7869	----	6950
10–12 inclusive	----	----	----	1000	----	1108	----	815	----	1242	----	1085	----	1036	----	1395	----	1975	----	2275

at many if not at most horizons, a succession of sandstone lenses occurs in nearly the same general position with reference to the more persistent layers. Study of the rocks in this part of the section as exposed in outcrop is likely to lead one to question the extended correlation of individual sands from one part of the oil and gas fields to another, as presented in Mr. Sisler's charts. Nevertheless, certain of these sands, such as the so-called Big Injun or Burgoon sandstone, appear to be traceable with considerable reliability. However, what is called the Big Injun in the northern part of the State is generally a combination of the lower part of the upper Pocono sandstone (or Burgoon) with the overlying Pottsville sandstone, the intervening Mauch Chunk shale and upper part of the Burgoon having been removed. For this reason the top of the Big Injun in places appears to be much too close to the coal beds of the Allegheny group. The combined thickness of the Pottsville and Burgoon at the north is not much if any greater than that of the Burgoon alone farther south. In instances such as that just described, the top of the Pottsville or Homewood sandstone may be separated by the Mercer shale so that the top of the Big Injun sand in that region commonly coincides with the top of the Connoquenessing sandstone.

Catskill group. Under this title are grouped sandstones and shales characterized usually by their red color. The thickness as described here ranges from 500 feet at the west to 900 feet or more farther east. The possible extension of the Catskill downward is further discussed under the heading "Chemung Group". This group has also been called the Venango and the Bradfordian. A section by Chadwick in the northwestern corner of the State includes:

Section of "Catskill" in northwestern Pennsylvania (Chadwick)

	Feet
Cussewago (Hayfield) shale	75
Cussewago sandstone	25
Riceville shale	100
Woodcock sandstone	20
Seagerstown shale	100
Salamanca (Millers) sandstone	12
Amity shale	125
Le Boeuf-Panama-Wolf Creek sandstone	15
Total	472 feet

The correlation of these sandstones with the named oil and gas sands is now being studied by Mr. Chadwick. I. C. White of the Second Geological Survey correlated the First, Second, and Third Venango oil sands with the Woodcock, Millers, and Le Boeuf respectively. Others have correlated the First sand with the Cussewago, while still others have thought the First sand was the same as the Berea. The shale members here, as in the Chemung, which are generally described as shales and flags or flaggy sandstones, become more shaly toward the west, and possibly more sandy toward the east. It may be that the Cussewago, Riceville, and Woodcock are the equivalent of the Hundred-foot sand farther south. In this report the Third sand of Venango County is correlated with the Salamanca. The Fifth sand forms the base of what is here called the "Catskill". (See further under Chemung.)

Chemung group. Typically the Chemung differs from the Catskill in being less red and more sandy. The thickness is from 1,200 to 3,900 feet. Chadwick has identified the following members in the northwestern part of the State:

Chemung rocks in northwestern Pennsylvania (Chadwick)

	Feet
Chadakoin shale and flags	325
Hindsdale ("Quarry") shaly sandstone	20
Girard shale and flags	225
Cuba sandstone	10-15
Northeast shale and flags	475
Shumla sandstone	40
Westfield shale and flags	160
Laona sandstone (Bradford sand?). petroliferous	20
Gowanda shale increasingly black to west	300
Dunkirk black shale	75
Total	1655

As stated above, the top of the Chemung is still a problem. By some, the top is given as in the Chadwick table; by others, the top of the group is put at the top of the Northeast member. Likewise, some draw the base of the group at the base of the Leona sandstone. Some confusion may be found between descriptions of the oil and gas sands in the several groups and the drawn plates. The whole matter should be fully cleared up when Mr. Chadwick's studies are completed. From his studies in the region of outcrop in New York, Mr. Chadwick has concluded that the Bradford sand of the Bradford field is the equivalent of the Leona sandstone.

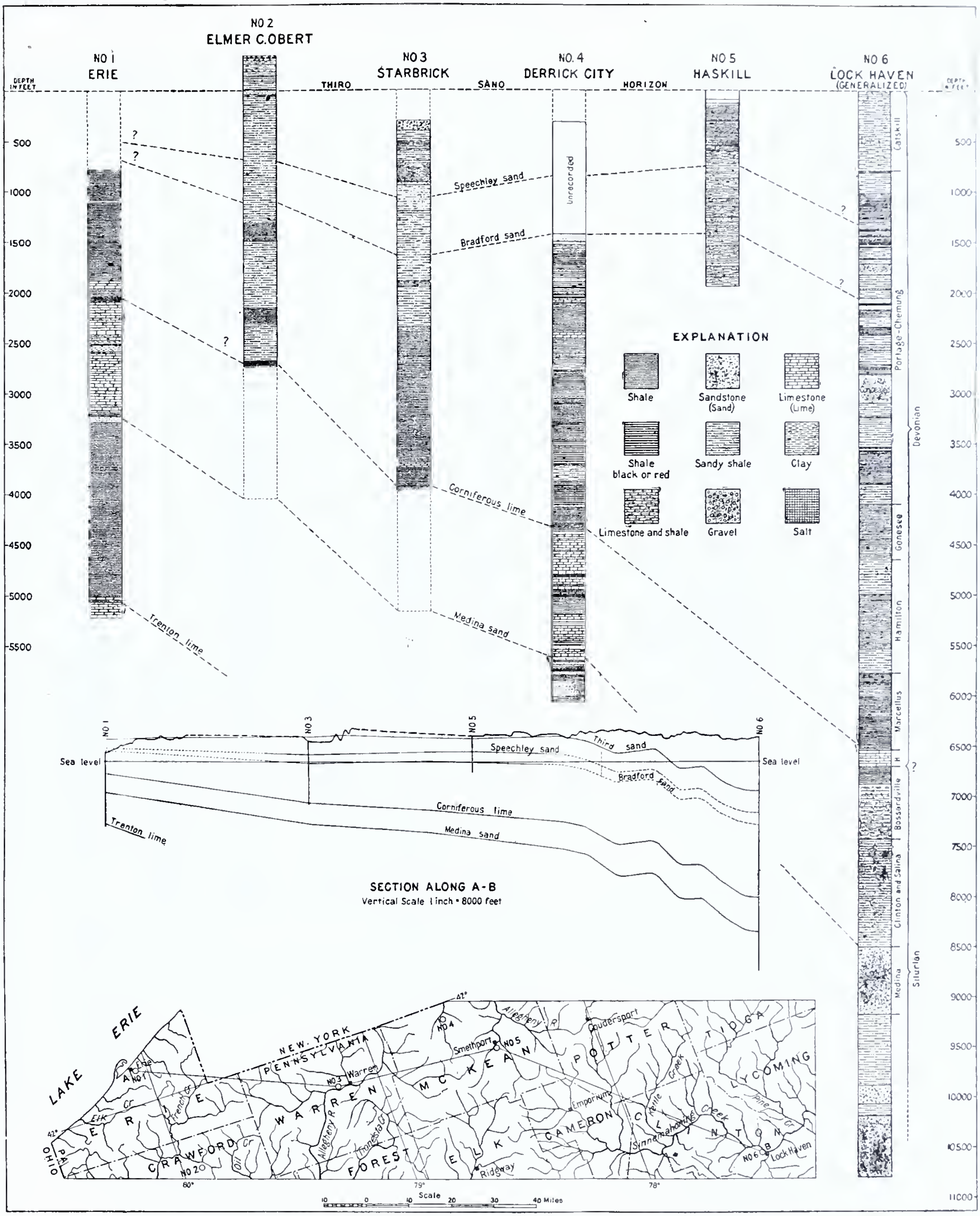
The thickness given for the Catskill in the table applies only to the red beds in northwestern Pennsylvania generally designated as Catskill in the past, and in accord with the boundaries given by Mr. Sisler on his charts and the composite sections beyond. It includes the rocks from the base of the Berea sandstone to the base of the Le Beouf (= Panama = Wolf Creek) sandstone. Traced eastward the base of the red beds descends stratigraphically, and in Bradford County lies on top of the Wellsburg sandstone which there in the type region forms the upper part of the Chemung. According to Chadwick, the lower red beds of the "Catskill" in the type Chemung region are equivalent to the Chadakoin, Girard (= Volusia) and Cuba sandstone (= Speechley sand,) at the west. It seems possible, therefore, that in the future the top of the Chemung will be defined as the top of the Wellsburg sandstone in the type locality, equivalent to the top of the Machias and Rushford of the Olean region, and to the top of the Northeast, Shumla, Westfield, and Laona (= Bradford oil sand,) of the Chatauqua-Erie-Crawford region. This would increase the thickness of the so-called "Catskill" downward from 550 to 615 feet, and reduce the thickness of the Chemung by a corresponding amount. Likewise, if the suggested correlations with the sands are correct, the "Catskill" will include all of the sands from the base of the Berea to the base of the Speechley.

Further, according to Chadwick, the Chemung in the type region includes the Cayuta shale below the Wellsburg sandstone. This, as interpreted by Chadwick, is the equivalent of the Gowanda and Dunkirk formations of farther west, the two having a thickness of 375 feet. If these are correctly interpreted as coming below the Bradford sand, all of the "sands" listed below the Bradford by Mr. Sisler, except the Oriskany and lower, will come in the Chemung.

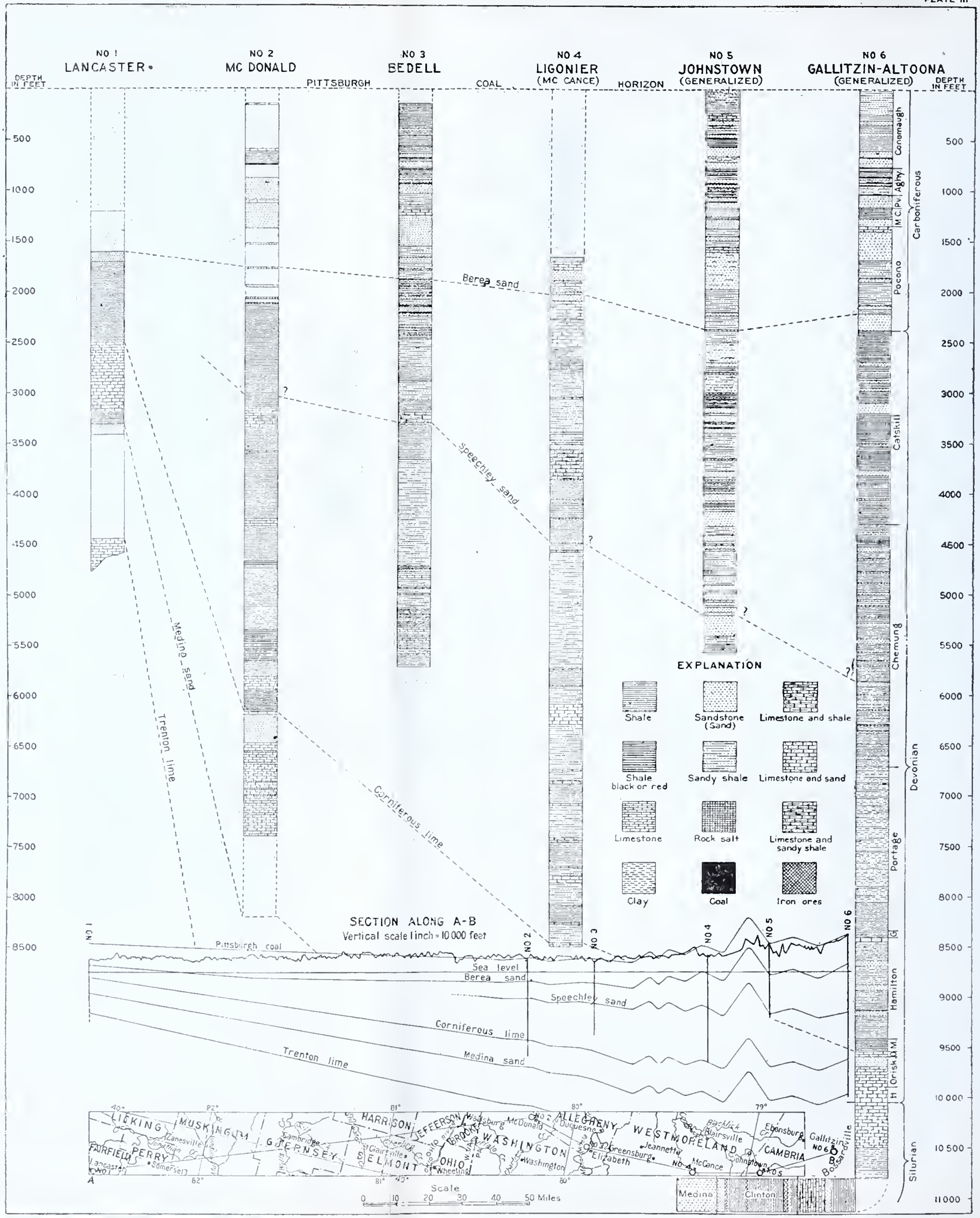
There is a marked thickening of most of the beds from west to east and from north to south. For example, according to Chadwick, the Chemung at Erie is 1,275 feet thick as measured in outcrop and in the deep well at Erie; 1,620 feet as measured along the shore of Lake Erie, and 1,800 feet on the Genesee River. The Portage is 225 feet thick at Erie, 507 feet thick on the east shore of Lake Erie, and 1,242 feet thick on the Genesee River. Chadwick draws the base of the Chemung from 100 feet (at Erie) to 550 feet (on the Genesee River) below the Laona sandstone, which he correlates with the third Bradford sand. This would make the Chemung group include all the Upper Devonian oil and gas sands shown on the general chart, including the Elk sands.

Portage, Genesee, Hamilton, and Marcellus groups. These groups seem not to contain oil and gas in Pennsylvania, except in Erie County, though the shales of these groups, especially the dark or black shales, probably served as source rocks.

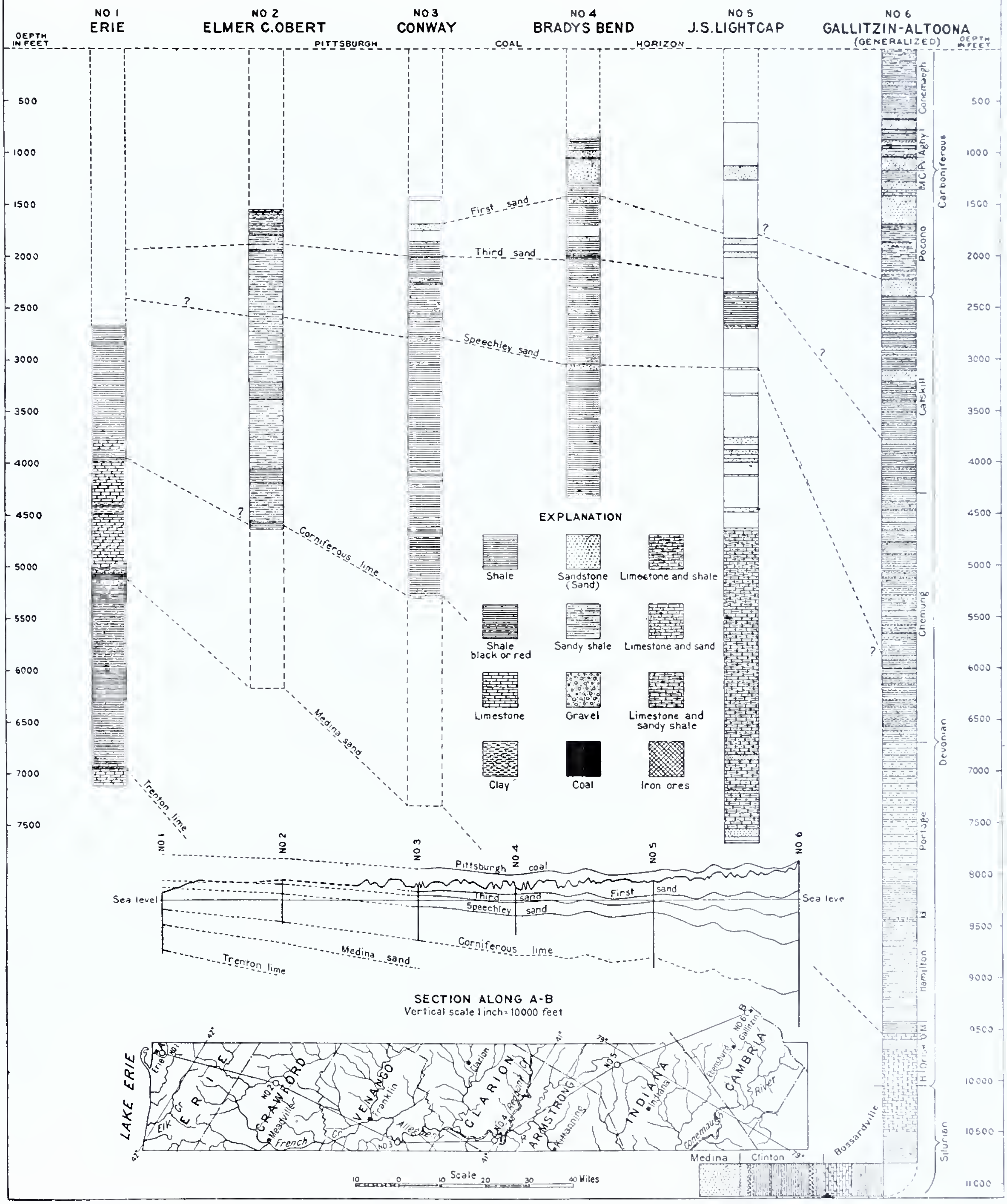
Onondaga limestone. This is a thin, widespread, partly cherty limestone, traceable from New York to Kentucky. As indicated in the preceding table the group is lacking at Lock Haven, and doubtless elsewhere, and ranges from 50 to 275 feet thick in most of the wells. The group has yielded oil and gas in other States, but only one well in Pennsylvania, that at McCance in Westmoreland County, has yet shown production.



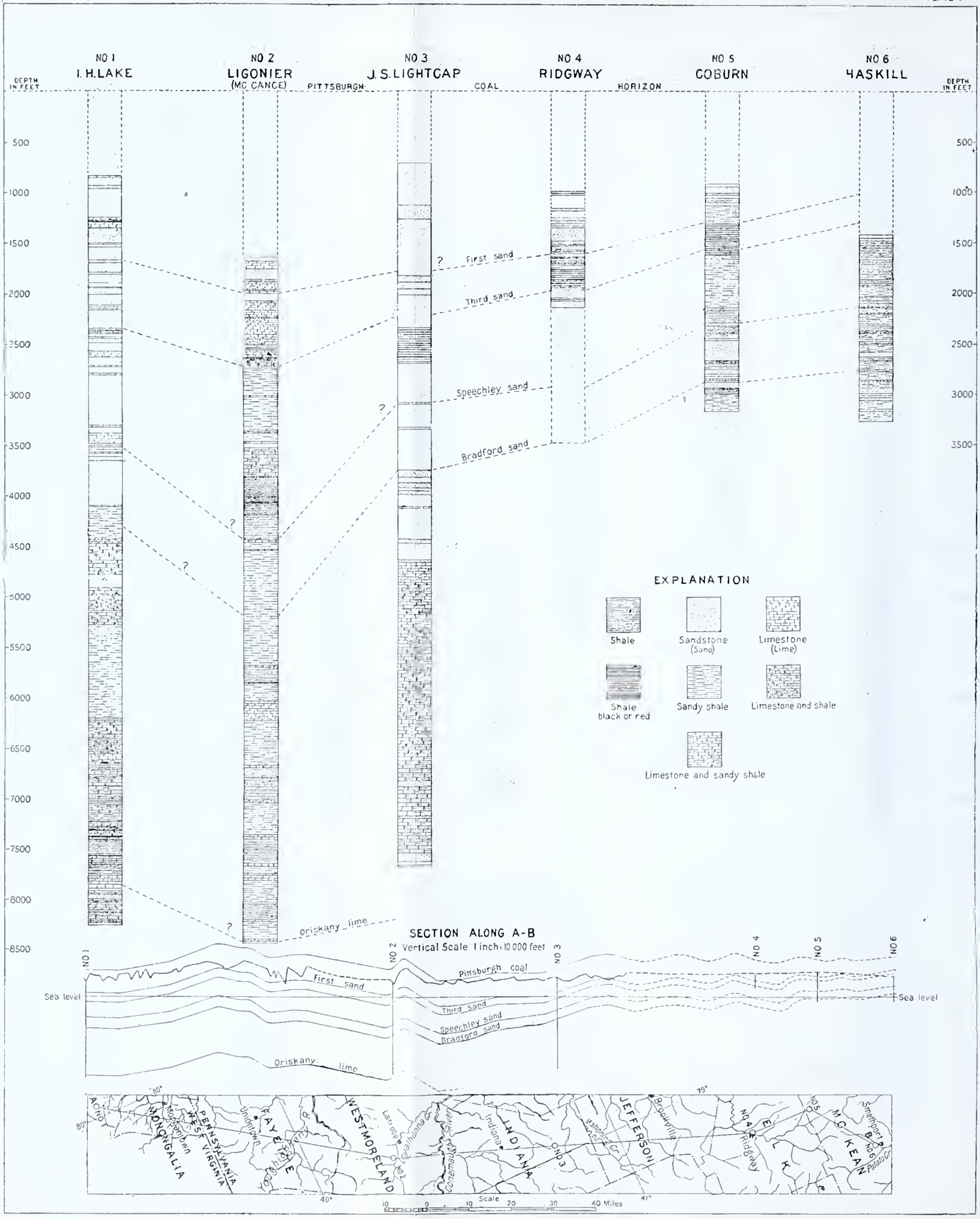
COLUMNAR AND LONGITUDINAL SECTIONS WITH GEOGRAPHIC LOCATIONS



COLUMNAR AND LONGITUDINAL SECTIONS WITH GEOGRAPHIC LOCATIONS



COLUMNAR AND LONGITUDINAL SECTIONS WITH GEOGRAPHIC LOCATIONS



COLUMNAR AND LONGITUDINAL SECTIONS WITH GEOGRAPHIC LOCATIONS

Oriskany group. This group consists of sandstone, chert, and limestone, though sandstone predominates. The group is much more variable than most of the formations. It is lacking in western New York, in Ohio, and on the Genesee River, also on long stretches along the outcrop of its horizon. In the central part of the State it is rather persistent, having a thickness of several hundred feet. It is reported 270 feet thick in the McDonald well in Washington County, though absent in many of the other wells.

SILURIAN SYSTEM

Below the Oriskany comes the Helderberg limestone forming the base of the Devonian. The figures given for its thickness possibly include the limy upper part of the Silurian, below which come the Salina beds, in places several hundred feet thick, containing beds of rock salt. At the base of the Silurian is the Medina series which in central Pennsylvania consists of three fairly thick members or groups. The upper group is the Tuscarora, a pure, gray quartzite which is much used for making silica brick and is about 400 feet thick. Below that is the Juniata, mostly red sandstone and shale (the Queenston of western New York), and the Oswego, a less massive, gray sandstone (Oneida of Second Geological Survey). The whole series has a maximum thickness of 2,000 feet or more. In western New York, the Tuscarora, or Albion, as it is there called, has thinned down to three thin members: the Thorold sandstone at the top, 5 feet thick, the Grimsby red beds, 110 feet thick, and the Whirlpool white sandstone, 25 feet thick. The "Medina" oil and gas of New York is said to come from the Whirlpool sandstone.

ORDOVICIAN SYSTEM

Trenton. The Trenton limestone occurs 2,500 to 3,000 feet below the top of the Tuscarora quartzite. It is the productive bed in parts of Ohio, Indiana, and elsewhere. This limestone was reached in the deep well at Erie without finding production.

COLUMNAR AND LONGITUDINAL SECTIONS

Plates II, III, IV, and V are sections of certain deep wells and measured outcrops reproduced from The Oil and Gas Fields of Pennsylvania, by Ashley and Robinson.* The locations of the wells are shown on the accompanying small scale maps.

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*Ashley, G. H. and Robinson, J. French. Oil and Gas Fields of Pennsylvania: Pa. Top and Geol. Survey, fourth series. 1922.

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CORRELATION OF OIL AND GAS SANDS

By J. D. Sisler

The productive oil and gas horizons of Pennsylvania are scattered through a thickness of 2 miles of rocks. About half of these rocks are shale, the remainder are sandstone, limestone, clay and coal. These rocks were formed slowly and under varied conditions throughout long periods of geologic time. Geologic changes and variations in deposition characterize the entire rock column, but, fortunately for geologic workers, several horizons are continuous and are more or less readily identified even throughout large areas. These horizon markers, in descending geologic order, are the Pittsburgh coal, Ames limestone, Upper Freeport coal, Vanport limestone, Big Injun sand, Hundred-foot sand (Gantz and Fifty-foot of Greene and Washington counties), the base of the red rock of the Catskill group in southwestern Pennsylvania, and the top of the pink rock, or Chemung group, in northern and northwestern Pennsylvania. All oil and gas sands occur at more or less definite points in relation to these familiar key rocks. The correlation of oil and gas sands involves the establishment of mutual relationships between sands and the identification of sands. Mutual relationships are primarily of two types, paleontologic and stratigraphic.

Surface correlation of rocks is established by both of these methods. Rocks are traced from one locality to another by observing and identifying the fossils which they may contain. They can also be traced by their stratigraphic relationships and their lithologic character. For example: the Ames limestone, which is an important key rock between the Pittsburgh and Upper Freeport coal beds, can be traced through Ohio, West Virginia and Pennsylvania by its distinctive fossils. In some localities fossils are rare in this limestone and the geologist must turn to some other means of identification. This can be done by observing the rocks which lie above and below it, and comparing them with the rocks at a locality where the absolute identity of the Ames is known by its fossils. If the exposures are meager and a limestone appears to be in the approximate position of the Ames, a hint as to its identity can be gotten from its lithologic character practically everywhere. It is a greenish, blocky limestone which turns yellow on long exposure to the weather. Another example is the Pittsburgh coal bed. This bed can be readily identified by its thickness and distinct physical character throughout the entire southwestern part of Pennsylvania. This coal bed occurs in a few places far east of the main area and here its physical character has changed, but fortunately the bed can be identified by its relationship to rocks above and below which maintain most of their marks of identification.

Surface correlation in western Pennsylvania is simple in comparison with the subsurface geology in the same area. In subsurface work the geologist must rely entirely upon churn drill logs. Immediately a personal element is introduced into the work which almost defeats the purpose of a drill log. This personal equation begins with the driller and extends through various hands to the geologist. Practically all the well logs in Pennsylvania are of the skeleton type, that is, they give only the depth to the various sands which were drilled through. Some of them give only the productive sands and very few records detail the physical characteristics of the rock through which the drill has passed. Nevertheless drill logs are a most valuable premise for subsurface work as sands which have produced oil and gas are more or less accurately located in most well logs.

In studying surface geology observations are made on every change in physical character of each outcropping rock. Sandstones come and go, limestones vary in thickness and physical appearance, shales thicken and thin. These same variations exist in the rocks below the surface. Casually, subsurface correlation without fossil evidence seems impossible. But it is not. If the geologist has thousands of churn drill records in the area in which subsurface correlation is being attempted, he has a substantial basis for his work. Out of these thousands of records only a few dozen may be complete, but a record here and there may disclose some little factor with which a certain sand or sands can be more or less definitely identified.

The Pennsylvania Topographic and Geologic Survey has in its files about 14,000 records of churn drill wells dating from 1860 to 1930. These records are of wells in every part of the oil and gas producing territory, and some of them are test wells in territory lying outside of the main oil and gas fields. These records vary much in their usefulness, but fortunately enough good records were collected to establish definitely the position of all the oil and gas sands in practically every township in the oil and gas fields.

The field correlation of oil sands was made by the pioneer oil men of Venango County. Before geologic workers entered Pennsylvania, oil well drillers had begun to recognize certain horizons in local areas. In those days the oil fields of Venango County were the center of attraction. When their sands were depleted drillers migrated north to the Bradford and Warren fields, and south to the Butler, Washington and Greene County fields. Each of them had his own peculiar ideas of the occurrence of oil and gas sands. When some little characteristic of its feel under the bit or the appearance of the cuttings led a driller to believe that a sand in a new field was the same sand which he had drilled in another field, he gave it the same name as the one he had previously drilled. In some instances the drillers were correct, but in most instances their incomplete observations led them astray. The inevitable result was that dozens of local names became established. One sand was known by at least a half dozen names in western Pennsylvania. The primary purpose of correlating oil and gas sands is to trace them from one field to another and establish their interval above or below a well known horizon. The correct correlation of oil and gas sands indicates the probable depth to drill, and it enables operators to foresee what lies ahead of the bit.

Absolutely accurate subsurface correlation of the oil and gas sands in western Pennsylvania can be obtained only by the microscopic and chemical examination of churn drill cuttings. In collecting samples of churn drill cuttings the personal element again enters. The core drill section eliminates the personal element, and gives the geologist material which is as close as possible to outcropping rocks. Before absolutely definite subsurface correlation can be accomplished, extensive core drilling like that which is now being done in the Bradford district, is necessary.

METHODS OF CORRELATION

The geologist who undertakes subsurface correlation must first familiarize himself, wherever possible, with the outcrop of the rocks in the territory which he is to study, and in adjacent territory. He should study the literature concerning the stratigraphy of the rocks and familiarize himself with their paleontologic, stratigraphic, and lithologic characters. After he has completed this study he should carefully note the salient and indisputable facts, but enter upon his own work with an unprejudiced mind. All available records of drilled wells in the area should be collected. Their selection should be made with much thought and careful observation. They should be as nearly representative of the area as possible, and the more complete they are the better they serve their purpose. Records having elevations above tide are most valuable. A record with no locality is practically useless. Records showing one or more definite geologic horizons, such as the Pittsburgh coal, Big Injun sand, and Hundred-foot sand, are of great value. If a record is obtained which shows all the sands and the shales between them, it should be studied carefully, particularly if it gives the color of the shales and the color and texture of the sands. Most geologic horizons have been named from type localities. The Pittsburgh coal obtained its name from its type locality at Pittsburgh; the Homewood sandstone from its outcrop at Homewood, Beaver County, Pennsylvania; and the Vanport limestone from its type locality at Vanport, Beaver County, Pa. Oil and gas sands obtain their names in various ways and from various localities. The Dunkard sands were named from Dunkard Creek, Greene County, where they were first found to be productive. The salt sands were so named because invariably they contained salt water. The legend of the Big Injun sand is interesting. One hot July afternoon, on a lease east of Washington, Pa., a tool dresser was laboring over a bit which needed resharpening after the screw had been let out only a few feet. He wiped the perspiration from his forehead and exclaimed, "Gosh, this sure is a Big Injun!" The Berea is so called because it was supposed to be the equivalent of the Berea grit of Ohio. The Gantz and Gordon sands were named from farms at Washington, Pa. The Bayard sand was first found on the Bayard farm near Waynesburg. The Elizabeth sand was first named in the Bedell well in Jefferson Township, Allegheny County. The Speechley sand was named from the Speechley farm near McPhersons Corner in Pine Grove Township, Venango County, where it has been a large producer of gas since 1885. The deeper sands, for instance, the Onondaga, Oriskany and Medina, have assumed the geologic nomenclature from localities in New York State where they outcrop.

The correlation of oil and gas sands is, simply stated, the tracing, identification, and comparison of the physical and chemical properties, the stratigraphic, paleontologic, and lithologic characters, from their type locality to other more or less distant points. To sum up: after a type locality has been established it is necessary to trace the sand from this locality into other pools.

The 14,000 well records in the Geological Survey files came from three sources: (1) Second Geological Survey of Pennsylvania, (2) records collected by the U. S. Geological Survey in cooperative work in Pennsylvania prior to 1919, and (3) 4,000 records collected by the author and his assistants since 1925.

These records, on 5 x 8 cards and sorted into counties and townships, were carefully examined and 2,500 of them were selected for plotting. The plotting was done on a printed strip on a scale of 1 inch equals 100 feet. These plotted well records contain all drilling information. Limestones were plotted in blue, coal in black, sandstones in orange, and shales according to their color. The driller's or company's correlations were noted after each sand.

The township was selected as the unit of correlation because township boundaries occur on many maps and on the map of the oil and gas fields which accompanies this report. Pool outlines were not chosen as the unit because these outlines are constantly changing and pools are, in some instances, known by many names.

The procedure of correlation is illustrated by using Whiteley Township, Greene County, as an example. The well records of this township were carefully studied and 20 were chosen from 60 which seemed to fairly represent the subsurface conditions throughout the entire township. The 40 records which were discarded were studied and notes made concerning them. The 20 type well sections were then laid on a long table, across which were tightly drawn strings which represented the approximate position of the top of each sand. The Pittsburgh coal, which is a very definite and easily recognizable horizon in all well logs in this township, was chosen as a datum plane for correlation. The plotted well sections were placed in order from east to west in the township, each one with the plotted position of the Pittsburgh coal coinciding with the string which represented that horizon. In this manner the correlations of the companies and drillers which appeared on the log could be compared with the actual position of the sand. For instance: the top of the Big Injun sand was displayed with all its variations at intervals below the Pittsburgh in a west-east direction across the township, and so with all of the sands above and below the Big Injun. The Gantz, for instance, maintained a very definite position below the Big Injun and the Pittsburgh. The well records were shifted back and forth, first on the string which represented the top of the Pittsburgh, then on the string which represented the top of the Big Injun, and then the string which represented the top of the Gantz sand. The obvious inaccuracies of correlations were corrected, and marked on the well section.

This method of primary correlation was satisfactory for a township which contained only 20 records, but it could not be used for correlating the sands throughout an entire county which contained more than 30 townships because room could not be provided for spreading out 500 or 600 records. After the primary correlation had been completed the second and final check correlation was made by plotting some 4,500 records 2/10 of an inch wide, on the edge of strips of cross section paper on a scale of 1 inch equals 200 feet. This greatly reduced the width and length of each section, and records for an entire county could be handled on a large board at an office desk. After the well sections had been reduced to a scale of 1 inch equals 200 feet, they were recorrelated in the same manner as in the primary correlations. When the records were placed close together in a west-east order in the township, most of the sands could be very readily identified in their respective intervals above or below a definite reference horizon, as the Pittsburgh coal, the Big Injun and Gantz sands.

But even 20 records were too many to handle for each township even though they would adequately show the position of the sands and the variation of deposition. It was necessary to reduce the information to a still finer point. The strips on which the well records were plotted were placed across the board on a definite line which represented the Pittsburgh coal. A blank piece of cross section paper was placed at the right-hand edge of the board. The highest and lowest points at which the top of each sand occurred below the Pittsburgh coal were indicated by dots on this piece of blank cross section paper. Likewise, the highest and lowest points at which the bottom of each sand occurred below the Pittsburgh coal were located. A line was drawn on the cross section paper which was midway between the dots which represented the highest and lowest top of the sand. Another line was drawn between the dots which represented the highest and lowest bottom of the sand. The space between the two lines which were thus obtained was colored in by orange pencil. This area represented the interval within which this sand ordinarily occurs below the Pittsburgh coal in this township. Each and every sand was located in a similar manner on the cross section paper. The resulting section has been called by the author a composite township section. It should not be confused with a generalized section because it does *not* show average thicknesses of sands. *It shows the range of the top and bottom of the sands above or below a definite reference horizon which in this township was the Pittsburgh coal.*

In Greene County some 30 composite township sections were made. Further generalization seemed necessary. The composite sections from townships in the southern half of Greene County were then placed on the drawing board and lined up on the Pittsburgh coal. Another composite section was made from them which represented the average position of the top and bottom of the sands below the Pittsburgh coal in southern Greene County. A similar section was made for the townships in the northern half of Greene County. These two composite sections were then averaged and a composite section which fairly represented the position of all the sands in Greene County was the result. This same procedure was followed in all the counties which are treated in detail in this discussion, with the result that all the oil and gas sands have been finally established in the geologic section and their identity is more or less accurately known.

As a further check of purely geologic nature, all the logs or sections of very deep wells which have been drilled in Pennsylvania were correlated geologically and the positions of the sands were checked against the nearest composite sections. This further correlation enabled the author to establish the geologic identity of many of the sands, although many type geologic localities are outside of Pennsylvania. This final geologic correlation was made only through the assistance of previous literature dealing with stratigraphic and paleontologic problems in West Virginia, Ohio, and New York. Each peculiar correlation problem will be discussed under the heading of the specific sand.

ACKNOWLEDGMENTS

The writer wishes to mention the names of a few of the men who have been particularly helpful in permitting the selection of data from their files, and by assisting in many ways in the compilation of this report. Harvey L. Applegate, Carnegie Natural Gas Company, Pittsburgh, Pa.; Edward Gaul, The Equitable Gas Company, Pittsburgh, Pa.; J. French Robinson and Fred Benkert, Peoples Natural Gas Company, Pittsburgh, Pa.; E. H. Tollefson, Columbia Gas and Electric Company, Pittsburgh, Pa.; Richard Waid, T. W. Phillips Gas and Oil Company, Butler, Pa.; J. G. Montgomery, Jr., United Natural Gas Co., Oil City, Pa.; and F. C. Deemer, Brookville, Pa. Numerous other officials of oil and gas companies have contributed much valuable information and assistance. The list would be entirely too long to publish.

M. N. Shaffner, Forrest Moyer, and Edward Barnsley of this Survey assisted in the office work, especially in drawing to scale the thousands of well records.

SEQUENCE OF SANDS

Pittsburgh coal. The rocks above the Pittsburgh coal in the Monongahela, Washington, and Greene groups have very definite characteristics but drillers for oil and gas pay little attention to them because no production has been found in them. The Pittsburgh coal is the highest geologic marker in the oil and gas region. It is a persistent bed, ranging from 5 to 9 feet thick in Greene, Washington, Allegheny, Fayette, and Westmoreland counties. Practically every record of a well that started above its horizon records this coal bed. The oil and gas sands in the southwestern counties of Pennsylvania are correlated and spoken of in reference to this key horizon.

Murphy Stray sand. A thin and nonpersistent sand occurs 75 to 110 feet below the Pittsburgh coal. Oil and gas have not been found in this sand. It is probably the geologic equivalent of the Lower Connellsville sandstone.

Murphy sand. This sand, the top of which lies at an average interval of 180 feet below the Pittsburgh coal, is at the geologic horizon of the Morgantown sandstone, which has its type locality at Morgantown, Monongalia County, West Virginia. It produced oil at Moundsville, Marshall County, West Virginia. This sand is probably the equivalent of the Mitchell sand of Ohio, which obtains its name from the small oil field a few miles east of Marietta.

Little Dunkard sand. This sand was named from Dunkard Creek, Greene County, where it produced some oil. It was originally thought to be the upper break of the Big Dunkard, but it appears to be a definite horizon with its top averaging 350 feet below the Pittsburgh coal. It is an irregular sand, with a maximum thickness of 60 feet. It probably corresponds with the First Cow Run sand of Ohio. The Conemaugh group of rocks, which contains this sand, is much thinner in Ohio, but the relative position of these two sands below the Ames limestone indicates that they are in the approximate position of the Saltsburg sandstone which has its type locality at Saltsburg, Indiana County, Pa.

Big Dunkard sand. The top of the Big Dunkard sand lies at an average interval of 460 feet below the Pittsburgh coal at its type locality on Dunkard Creek in southern Greene County, where it produced considerable quantities of oil in 1863 in the early days of the industry. This sand has been erroneously called the Second Cow Run sand. It is indisputably at the horizon of the Upper and Lower Mahoning sandstones, which overlie the Upper Freeport coal. The sand is split into two benches in numerous well logs. Its maximum thickness at its type locality is 120 feet. The Conemaugh group thickens eastward and northward so that the interval between the Pittsburgh coal and the top of the Big Dunkard sand increases in these directions. In Allegheny County the top of the Big Dunkard is 500 feet below the Pittsburgh coal, but the sand is thinner than in Greene County.

Upper Freeport coal. The Upper Freeport coal lies from 500 to 600 feet below the Pittsburgh coal in southwestern Pennsylvania. It is separated from the base of the Big Dunkard sand by a few feet of shale. This coal bed is a good horizon marker in Allegheny, Armstrong, and southern Butler counties. It lies at the top of the Allegheny group of rocks.

Upper Gas sand. This sand is the first of a series of three sands in the Allegheny group. It is the stratigraphic equivalent of the Freeport sandstone which outcrops on Allegheny River at Freeport. Some gas has been found in it in Greene County, and considerable quantities of gas have been produced from it in West Virginia. It lies at an average interval of 590 feet below the Pittsburgh coal in Greene County, 600 feet in Washington County, and 590 feet in Allegheny County.*

Middle Gas sand. The top of the Middle Gas sand lies at an average interval of 670 feet below the Pittsburgh coal in Greene and Washington counties. In southern Allegheny County its top averages 660 feet below the Pittsburgh coal. This sand probably corresponds to the Kittanning sandstone which outcrops on Allegheny River at Kittanning. It is of no importance as a gas producer, although it is the thickest of the three Gas sands. It has a maximum thickness of 100 feet.

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*Pennsylvania Geol. Survey Bull. M6-Pt. 2, the interval from the Pittsburgh coal to the top of the Freeport sandstone is given as: Greene County 650 feet; Washington County 600 feet; Allegheny County 665 feet. G. H. A.

Lower Gas sand. The top of this sand lies at an average of 760 feet below the Pittsburgh coal in Greene and Washington counties, and in Allegheny County at 730 feet. It probably corresponds to the Clarion sandstone which lies near the base of the Allegheny group.

First Salt sand. This sand is the uppermost of three sands in the Pottsville group. It corresponds very definitely to the Homewood sandstone which is typically exposed at Homewood, Pa. The top of the First Salt sand lies at an average interval of 830 feet below the Pittsburgh coal in Greene County, at 810 feet in Washington County, and at 830 feet in Allegheny County. The First Salt is the thickest and most persistent of the three Salt sands. Its maximum thickness of over 100 feet occurs in Washington County. The Salt sands are so named because they invariably contain large quantities of salt water.

Second Salt sand. The average interval between the top of the Second Salt sand and the Pittsburgh coal is 940 feet in Greene and Washington counties, and 930 feet in Allegheny County. This sand is not as persistent in its occurrence as the First Salt sand. It also contains salt water and is the probable equivalent of the Upper Connoquenessing sandstone which outcrops on Connoquenessing Creek, Butler County, Pa.

Third Salt sand. The top of the Third Salt sand averages 1,060 feet below the Pittsburgh coal in Greene and Washington counties, and 1,020 feet in Allegheny County. This sand also contains salt water in Pennsylvania. In West Virginia it has produced oil in Wetzel and Tyler counties. It probably corresponds to the Lower Connoquenessing sandstone which outcrops on Connoquenessing Creek in Butler County, Pa. It is directly underlain by red shale which marks the top of the Mauch Chunk series.

Little Lime. This limestone is the northern extension of the Greenbrier limestone of West Virginia. It ranges from 5 to 30 feet thick in southwestern Pennsylvania, and its top lies at an average interval of 1,175 feet below the Pittsburgh coal. Its occurrence is persistent only in Greene County. North of this county it was not deposited or was removed during pre-Pottsville erosion interval. The Little Lime was known as the Salvation sand in Greene County.

Pencil Cave. A few feet of bright red shale separate the Little Lime from the Big Lime. It has been called the Pencil Cave because it breaks up in long splintery pieces and caves into the well. It is an excellent horizon marker in Greene County and lies at an average interval of 1,190 feet below the Pittsburgh coal. These few feet of red shale are the thin western edge of the Mauch Chunk red beds that are more than 2,000 feet thick on Lehigh River.

Big Lime. The Big Lime is also known as the Mountain limestone. It is the stratigraphic equivalent of the Loyalhanna limestone. It occurs directly on top of the Big Injun sand and lies between the Mauch Chunk and Pocono series. In Greene County the top of this "lime" is on an average of 1,200 feet below the Pittsburgh coal. Its thickness varies but is generally at least 25 feet. It occurs in Washington County, but is lacking to the north.

Big Injun. The Big Injun is one of the most readily recognized rock strata in southwestern Pennsylvania. It is a hard, massive gray sandstone which is generally over 200 feet thick. In Greene County the average interval between the top of the Big Injun and the Pittsburgh coal is 1,230 feet; in Washington County this interval is 1,140 feet, and in Allegheny County it is 1,120 feet. The interval decreases northward because of the unconformity which has removed at least part of the Mauch Chunk series. The Big Injun is a very prolific source of both oil and gas in West Virginia. In Pennsylvania it is a gas horizon, particularly in Greene and Washington counties. Stratigraphically it is the equivalent of the Burgoon member of the Pocono series or, at the north, of the basal Burgoon and lower Pottsville.

Squaw sand. This sand is separated from the Big Injun by 100 feet of shale in Greene County. The average interval to the Pittsburgh coal is 1,580 feet in Greene County, 1,570 feet in Washington County, and 1,520 feet in Allegheny County. In the latter county it is separated from the base of the Big Injun by only 40 feet of shale. The Squaw sand probably correlates with the conglomeratic phase at the top of the Cayuga group of Mississippian rocks in Ohio. The Squaw is extremely irregular in its occurrence, and cannot be traced continuously through large areas.

Berea sand. The identity of the so-called Berea sand of Pennsylvania has long been a matter of controversy among geologists. An unconformity which occurs at this horizon makes its identity very obscure in subsurface records. The Second Pennsylvania Geological Survey noted the persistence of the Pithole grit in Venango County, and considered it the equivalent of the Berea sand of Ohio, because of its stratigraphic relationships. Dr. Orton of the Ohio Geological Survey correlated the Berea grit with the Corry sandstone of Pennsylvania, which was later concurred in by Girty and others.

In Ohio the Berea ranges from 10 to 200 feet thick. This group is composed of sandstones with shale partings, and the upper part is known to the oil drillers as the Berea sand. It lies 1,700 to 1,800 feet below the Pittsburgh coal in the southwest corner of the State and is in the lower part of the Pocono series.

Murrysville sand. The Murrysville sand appears to have been deposited from the east. It is thickest in Westmoreland, Armstrong, Indiana and Jefferson counties and is absent in Greene, the western part of Washington, Beaver, and the western part of Butler counties. It thins gradually from east to west. It is the basal sandstone in the Pocono series and is about 1,750 to 1,850 feet below the Pittsburgh coal in Allegheny, Washington, Fayette, and Greene counties.

Hundred-foot sand. J. F. Carll of the Pennsylvania Second Geological Survey regarded the First Venango sand at Tidioute as the Salamanca conglomerate, and published a plate* of oil well sections, showing the correlation of the Venango sands from Oil City to Franklin and Clarion. This section was recently connected by Munn to the Kittanning-Rural Valley region, which was studied by Butts, with the result that the Hundred-foot sand of southwestern Pennsylvania has been satisfactorily correlated with the Venango First oil sand.

The detailed study of well logs for this publication has further substantiated this correlation. The writer has been able to trace the Hundred-foot sand continuously through Greene, Washington, Allegheny, Butler, Armstrong, and Clarion to Venango County, and the identity of the Hundred-foot sand as the Venango First is no longer a question of much doubt. The Hundred-foot sand is the equivalent of the Gantz and Fifty-foot sands in Greene County, Pennsylvania. It is the uppermost sand in the "Catskill" series and is around 2,000 feet below the Pittsburgh coal.

Thirty-foot sand. The Thirty-foot sand directly underlies the Hundred-foot, and is separated from it by a few feet of shale. In the western part of Greene County, it is known as the Nineveh, and in Venango County it or a stray between the Hundred-foot and Thirty-foot is known as the Red Valley. The Red Valley sand is probably of the same geologic age as the Hundred-foot and the Venango First. The Thirty-foot sand is underlain by red shale in many localities. In Greene County, this bed is underlain by 60 to 80 feet of red shale which is believed to be the equivalent of the Bedford shale of Ohio. This red shale appears locally in other counties in Pennsylvania in the eastern part of the oil and gas fields. The top of the Thirty-foot commonly is 100 to 150 feet below the top of the Hundred-foot sand.

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* Carll, J. F., Oil Region: Pa. Second Geol. Survey, Rept. III, maps and charts, Plate VI, 1880.

Snee sand. The Snee sand is present in isolated sections of Greene and Washington counties. It appears of good thickness at its type locality in northern Allegheny County and is found as a very persistent sand in all of the counties in the central and northern parts of the oil and gas fields. The Snee occurs interbedded in red or olive-green shales which are Catskill in age. It is equivalent to Blue Monday, Boulder, and Hickory sands.

Gordon Stray sand. This sand is quite similar to the Snee in its occurrence. The Gordon Stray is persistent in practically all the counties which produce oil and gas. This sand is interbedded in red and olive-green shales in southwestern Pennsylvania, and in the central and northern parts of the field. The shales are typically red. It has been locally miscorrelated as the Snee. The Gordon Stray probably corresponds to the Second sand of the Venango group.

Gordon sand. The Gordon is a very persistent sand which occurs throughout the entire oil and gas field of Pennsylvania. It is of Catskill age, is interbedded in red shale, and is locally known as the Third sand. This sand lies at the approximate geologic horizon of the Venango Third, 225 to 325 feet below the top of the Hundred-foot, and 2,100 to 2,200 feet below the Pittsburgh coal.

Fourth sand. This sand is quite similar to the Gordon in its geologic occurrence. The Fourth sand occurs in the Catskill red beds throughout the entire oil and gas fields.

Fifth sand. The Fifth sand lies near the base of the Catskill series and occurs interbedded in red or olive-green shales. It is known locally as the McDonald sand.

Bayard sand. The Bayard sand is persistent in southwestern Pennsylvania, but in the central and northern parts of the oil and gas field it occurs as a lenticular sandstone interbedded in red shale. The Bayard is locally known as the Fifth sand. Beneath it in many places are one or more sands known as the Bayard Stray and Stray Stray. The Bayard is reckoned to be 2,300 feet below the Pittsburgh coal in Fayette County and more than 2,400 feet in Greene County.

Elizabeth sand. The Elizabeth sand occurs interbedded in red shales. Its top is 150 to 250 feet below the top of the Bayard sand and 600 to 700 feet below the top of the Hundred-foot. Locally two or three stray sands occur in these shales below the Elizabeth.

Warren group. This group of sands lie in the upper half of the Chemung group of red and pink shales. The sands are extremely irregular in occurrence and variable in thickness. In some localities five of these sands are present, but usually only two or three can be identified.

Speechley Stray sand. This sand lies above the Speechley and below the lowest Warren sand.

Speechley sand. The Speechley sand is in the Chemung group of red shales, and corresponds in geologic position with the Glade sands of Warren County, and the First Bradford of the Bradford oil field.

Allegheny sand. This sand has been recognized for the first time by these correlations. It lies directly beneath the Speechley, and above the Tiona. It first appears in records of wells on Allegheny River north of Pittsburgh and seems to be continuous sand throughout the Allegheny River drainage basin. The Allegheny has locally been mistaken for the Speechley.

Tiona sand. This sand is very definite in its occurrence throughout the entire oil and gas region. The Tiona is one of the few sands which is identified in large areas by oil well drillers. It is approximately equivalent to the Clarendon sand of Warren County.

Balltown group. A group of two sands underlies the Tiona. The First Balltown corresponds in stratigraphic position with the Gartland and Cherry Grove sands. The Second Balltown is in the approximate geologic horizon of the Chipmunk of the Bradford District.

Sheffield sand. The Sheffield sand is a very persistent sandstone but is extremely variable in thickness. This sand probably corresponds to the Cooper sand of Warren County, and is in the approximate stratigraphic position of the Second Bradford sand of the Bradford District.

Bradford sand. This sand which is so important throughout the oil and gas fields is very difficult to correlate. The Bradford sand of the Bradford District is at the approximate stratigraphic position of the Third Bradford sand in the remainder of the oil and gas fields. It occurs in the Chemung. The Bradford sand of the Bradford District thins out and disappears a short distance beyond the productive area of this pool and a sand appears at approximately the same stratigraphic horizon in other parts of McKean County. This sand has been traced through much of the oil and gas region.

Lewis Run sand. This sand occurs in the Bradford District below the Third Bradford. It probably correlates with the Windfall sand which is called the Fourth in the northeastern part of the Bradford District. These sands do not seem to occur outside the Bradford District.

Kane group. This group of three sands occurs throughout the entire oil and gas region. The Kane of the Bradford District does not correlate with the Kane sand of the Kane District.

Elk group. This group of sands is extremely variable in thickness and occurrence and is of greatest importance in the eastern part of the oil and gas field.

SUPPLEMENTAL NOTES

The following notes by counties are information that could not be shown on the charts:

ALLEGHENY COUNTY

The Murrysville, Gantz, Fifty-foot, Thirty-foot, Gordon, Fourth, Fifth, Bayard, and Elizabeth sands are the principal oil and gas producers of Allegheny County. The Murrysville, Gantz, Fifty-foot, Gordon and Bayard are the most persistent of these sands.

The Pittsburgh coal is not present in all Allegheny County. The sands lying between it and Big Injun do not produce oil and gas at any point within the county, and they will not be discussed. They are, in descending order, Murphy, Little Dunkard, Big Dunkard, Upper, Middle and Lower Gas, First, Second, Middle and Third Salt sands.

The oil and gas sands of Allegheny County with the exception of the Elizabeth are correlated with those of Greene and Washington counties. This sand has its type locality in the Bedell well in Jefferson Township. At this place it lies approximately 100 feet higher than the sand which is called Elizabeth in Washington County. It is doubtful whether the sand in Elizabeth Township is the same sand as that found in the Bedell well, unless a thickening of 100 feet in the rocks takes place along Monongahela River.

The Speechley of Allegheny County may not be the same sand as the Speechley in Armstrong and Butler counties, as it is approximately 100 feet lower in the geologic section, but the Speechley of Allegheny County is probably the same sand as the Speechley in Greene and Washington counties.

In addition to these general statements, the following notes make record of certain facts which do not appear in the sections beyond. The sands are described in order from top to bottom.

The Big Injun in Plum Township may be locally joined with the Squaw sand or separated by from 0 to 60 feet of shale. The Second sand in South Fayette Township occurs only as three rather persistent sandy strata in a space of 100 feet. The unusual thickness of the Gordon Stray in Snowden Township suggests that locally the Snee is joined with it. In the Sewickley district, the upper division is from 0 to 20 feet thick, averaging 10 feet; and the bottom is from 10 to 30 feet, averaging 15 feet, separated by a few feet of shale. In Pine Township the upper division is from 5 to 50 feet thick, averaging 10 feet; and the lower division from 5 to 15 feet thick, averaging 10 feet, with 20 feet of shale between the two.

The Fourth, Fifth, and Bayard sands are poorly represented in Findley, Kennedy, and Robinson townships and correlation is nearly impossible. The Bayard Stray sand is underlain by three lenticular sands in Baldwin Township and by two in Mifflin Township, with a maximum thickness of 10 feet.

ARMSTRONG COUNTY

The Murrysville, Hundred-foot, Thirty-foot, Gordon, Fourth, Fifth, Bayard, Speechley Stray, Speechley, Tiona, Balltown, and Bradford sands are the principal gas-producing horizons. Locally the Snee, Gordon Stray, and Elizabeth sands produce gas.

The Vanport limestone is found in practically every well log and is an excellent horizon marker. The Murrysville and Berea sands occur at a very definite interval below the Vanport. In some localities these two sands are separated by a few feet of shale, but their identity can readily be determined by their difference in physical character. The Murrysville in Pine Township is not as thick and massive as in the rest of the county.

The Hundred-foot, on which the correlation of the sands in this county was based, is a very persistent sand that occurs midway between the Vanport limestone and the Speechley sand at 1,020 feet below the Vanport.

The unconformity above the Big Injun sand is very pronounced in this county and makes the determination of the exact top of the Big Injun very difficult. In numerous localities the Salt sands rest on the Big Injun and the combination of the lower Salt sand and the Big Injun is known as the Seventy-foot sand. This sand usually contains water and is not therefore a favorable gas-producing horizon. The Squaw sand, which lies below the Big Injun, is very massive and persistent, but does not produce gas.

The Second Gas sand, which underlies the Squaw, produces some gas in Indiana County, but in Armstrong County it is not an important horizon for gas. It is not persistent in occurrence or regular in thickness.

The Berea sand is present in twenty-four townships. It is not a persistent sand and is entirely absent in large areas. Where present it ranges from a few feet to 120 feet thick and is locally a possible gas-producing horizon.

The sands above the Murrysville are not discussed in detail in this chapter because they are not productive. The Thirty-foot sand is joined with the Snee in North Buffalo, Kittanning, and Plum Creek townships.

In Pine Township the Gordon Stray, Gordon, Warren group and Speechley Stray, Fourth, Fifth, Bayard, and Elizabeth sands are thin and irregular, though locally massive and possible gas-producing. The Gordon sand splits into two divisions in East Franklin, Perry, and Hovey townships. In Perry and Hovey townships, the sands below the Gordon have been very little drilled, though the Speechley, Tiona, and Bradford appear to be persistent and may contain gas.

The Elizabeth sand is very thin and irregular, or represented by a few feet of sandy shale in Burrell, Madison, and Bradys Bend townships. The Warren group likewise is represented in many townships by only 2 or 3 local and variable sandstones or by sandy lenses in the shale. This is true of North Buffalo, Burrell, Bethel, Manor, Plum Creek, Cowanshannock, Boggs, Madison, and Bradys Bend townships.

The Speechley Stray sand in Gilpin, Parks, and Plum Creek townships is represented by only thin sandstone lenses. The Speechley sand appears in two divisions in Kittanning, Plum Creek, and Washington townships.

The Balltown sands in Bethel, Gilpin, and Valley townships are represented only by sandy lenses in the shales. In Mahoning Township the First Balltown is likewise represented by a few feet of sandy shale. The Sheffield sand in Kiskiminetas, North Buffalo, and West Franklin townships is represented by 20 to 30 feet of sandy shale.

The Bradford sands vary from locally massive to thin and sporadic sands, especially the latter in Burrell, Bethel, and Red Bank townships. In Gilpin, Bethel, Manor, Kittanning, and Plum Creek townships the Kane group is represented by three lenticular and sporadic sands that may locally produce gas. The Second Kane sand in Bradys Bend Township is fairly persistent and from 0 to 80 feet thick.

BUTLER COUNTY

The most definite horizon in the oil and gas fields of Butler County is the Hundred-foot sand. It is present in practically every well, and its physical characteristics are recognized by all drillers.. The Hundred-foot, Butler, Thirty-foot, Gordon, Fifth, and Speechley sands are the most productive horizons of the county.

The sands above the Hundred-foot sand in Cranberry Township are seldom placed accurately in the logs. As a result of unconformity the top of the Big Injun is lacking and the Salt sands lie directly upon it. The Salt sands are not important in Butler County. The Big Injun is always present with the Squaw sand beneath it as in the counties of southwest Pennsylvania.

The Butler, Thirty-foot, and the Butler Salt appear to be the equivalent of the Berea sand. The Murrysville lies between it and the Hundred-foot. These names have also been applied locally to the Murrysville. In Jackson Township the Berea sand is thin and lenticular; in Donegal Township it is locally in two divisions.

The Thirty-foot sand is locally divided into two divisions in several of the townships.

The Gordon sand is replaced by sandy shale in Brady and Worth townships.

Little information is available regarding the sands below the Fifth in Allegheny township. The sands below the Gordon sand are irregular and variable in Gordon, Middlesex, Forward, and Slippery Rock townships. In Cranberry and Penn townships the sands below the Fifth are irregular and variable.

CLARION COUNTY

Correlation of the sands in Clarion County with those of Venango County indicates very clearly that the Hundred-foot sand is the equivalent of the First sand of Venango County, that the Thirty-foot is the Second sand, and the Snee or possibly the Gordon Stray is the Third sand. Sands in the stratigraphic horizon of the Hundred-foot, Thirty-foot, Snee and Gordon Stray have been called First, Second, and Third Clarion. This has been very misleading. The First Clarion sand is the Hundred-foot or the Thirty-foot, according to the locality. The Hundred-foot sand is very persistent and is underlain by an unmistakable persistent red shale. The Speechley occurs at a very constant interval below this red shale so that definite correlation of the oil and gas sands of this county is possible.

The sands lying above the Berea are rarely productive in Clarion County. In some localities the Vanport limestone lies about 100 feet above the Big Injun. Throughout parts of this region the Pottsville rests upon the Pocono and the Pottsville and Pocono combined make up the Big Injun. The Berea and Murrysville occur locally in Perry, Knox, Richland, and Mill Creek townships.

In Farmington Township there is locally a sand 5 to 30 feet thick, averaging 10 feet, which may be a lower division of the Hundred-foot, or may be the equivalent of the Red Valley of Venango County. Likewise the so-called Thirty-foot sand in Madison Township probably is equivalent to the Red Valley sand of Venango County. In Piney Township the Thirty-foot sand appears to have joined the Hundred-foot sand. In Limestone Township both the Gordon Stray and the Gordon are replaced by sandy shale.

Between the Fifth sand and the Speechley in Salem, Beaver, Paint, Highland, Farmington, Elk, and Ashland townships there appear to be four or five irregular sands difficult to correlate, but locally oil and gas-producing.

The Bayard sand in Madison Township is thin and irregular. The Elizabeth sand is represented in Limestone Township by a thin stray sand. In Piney Township there are three stray sands below the

Elizabeth. In Madison Township red shale, averaging 300 feet thick, occurs 560 feet below the top of the Hundred-foot sand. In Knox Township a similar shale occurs at 650 feet below the Hundred-foot sand. In Perry, Washington, Richland, Salem, Beaver, and Paint townships, the sands below the Speechley are irregular and sporadic. In Clarion Township the Allegheny sand is locally in two divisions. In Toby Township the Second Balltown sand is present, but below that other sands are sporadic and irregular. In Knox Township sands are identified down to the Sheffield, below which are four to nine unidentified sands. In Mill Creek Township the Kane sands occur, but they are thin and irregular.

ELK COUNTY

The oil and gas sands of Elk County have not been correlated with the sands in the main part of the oil and gas field. Large areas are yet to be drilled. All sands are represented from the Berea to the Elk group. The Speechley, Tiona, Balltown, Sheffield, First, Second and Third Bradford, First, Second and Third Kane, and the First, Second and Third Elk are the important producing sands.

The top of the "Pink Rock" which lies at an average interval of 620 feet above the top of the Speechley is a very definite horizon marker and the sands are correlated with reference to it.

The Thirty-foot, Snee, and Gordon Stray sands in Millstone Township are represented by a sandy horizon 150 feet below the Hundred-foot sand. In Highland, Ridgway, and Spring Creek townships sands above the Speechley Stray are represented by thin and irregular sands which are not readily correlated.

The shallow sands lie in the approximate geologic position of the Bayard and Elizabeth sands of the main oil and gas-producing territory. These sands are thin and irregular in occurrence, but are locally suitable horizons for gas.

In Horton, Fox, Jay, and Benezette townships very little drilling has been done, and therefore little is known of the sands which occur there.

The Sheffield, and First and Second Bradford immediately underlie the Speechley and are locally favorable horizons for gas. Little is known concerning the sands which lie below the Second Bradford.

FAYETTE COUNTY

The sands of Fayette County are very similar in physical character and occurrence to those of Greene County. The Big Injun is the most persistent sand. The Gantz, Fifty-foot, Gordon, and Fourth are persistent and productive gas horizons. The sands above the Big Injun probably will not be important producers of gas.

The information concerning the sands in Fayette County is meager. Few wells have been drilled and very few records preserved. Future drilling will indicate which sands are gas reservoirs. Large areas in Fayette County that probably will be productive have not been thoroughly tested.

The sands lying between the top of the Big Injun and the Pittsburgh coal are only fairly well developed in German Township. The Little Dunkard which lies at the average interval of 460 feet below the Pittsburgh coal may locally produce gas, while the Big Dunkard at an average interval 640 feet below the Pittsburgh coal is locally a massive sandstone. The Salt sands in German Township form an irregular group occupying an interval of 220 feet; these sands are variable in Redstone and Luzerne townships.

The Big Injun is a double sand in parts of German Township. In Lower Tyrone Township, the Second Gas, Berea, and Murrysville sands are represented by sandy horizons in shale 100 feet thick. The Gordon sand is double in Springhill and Menallen townships. In Perry Township the Fourth, Fifth, and Bayard sands are variable in occurrence and thickness.

FOREST COUNTY

The oil and gas sands of Forest County resemble very much those of Venango County. Their stratigraphic position is practically the same. In addition to the three Venango sands, the Speechley, Tiona, and Third Bradford sands locally are massive and are oil and gas reservoirs.

The Venango First sand or Hundred-foot is the shallowest producing sand. It is overlain by the usual group of sands including the Berea which is the probable equivalent of the Pithole Grit. The Murrysville sand (basal Berea) which lies directly above the Venango First or Hundred-foot in Clarion County is not present in Forest County, but is replaced by sandy shale.

The Venango group of sands in Harmony Township is obscure and its identification uncertain because of its changed character.

The Elizabeth, Elizabeth Stray, First, Second and Third Warren sands occur in Green Township but are local and irregular. The same is true in Tionesta Township. In Hickory Township there are four strays between the Venango Third and First Warren. In Kingsley Township there are three strays between these two sands.

The Tiona sand is generally absent in Tionesta Township. The sands below the Speechley have not been well tested in Hickory and Harmony townships.

Below the Balltown sands there are generally from four to six sands which represent the Sheffield, Bradford, and Kane sands. Locally these become massive and may produce oil or gas. These lower sands, however, have been very little drilled.

GREENE COUNTY

The following notes supplement the charts of oil and gas sands in this county.

The Middle Gas sand is lacking in Jefferson Township. Locally it is split, and has from 20 to 40 feet of shale between the benches in Dunkard Township, from 10 to 50 feet in Perry and Aleppo townships, and up to 40 feet in Center Township.

The Salt sands in Dunkard Township are represented by hard gray and white sands in an interval of 220 feet. In Greene Township, the Second Salt sand locally occurs in two divisions, of which the lower reaches a thickness up to 60 feet.

The Maxton sand is commonly thin and irregular, occurring only in Dunkard Township. The Little Lime, Pencil Cave, and Big Lime occur in all townships and are readily recognized.

The Berea is split in several of the townships. In Gilmore Township it is in two divisions separated by 30 feet of shale.

The Fifty-foot sand in Dunkard Township is a hard gray massive sandstone, locally red, that in places coalesces with the Gantz into the Hundred-foot sand. In Franklin Township it is also in two divisions separated by 5 to 50 feet of shale. In Whiteley Township it is a massive white sandstone.

The Gordon sand is split in several of the townships. In Dunkard Township it is found usually in two benches separated by 5 feet of shale.

INDIANA COUNTY

The Second Gas sand is probably represented in southwestern Indiana County by a stray sand. In Canoe Township the Second Gas and the Berea are united into a massive sandstone which is not productive. The Gordon Stray in West Mahoning Township is represented only by sandstone lenses and shale. In Canoe Township the sands from the Fourth to the Elizabeth Stray inclusive are sporadic and irregular lenses in red shale. In East Mahoning Township the Fifth sand is represented by a few feet of sandstone and red shale. The Elizabeth sand in South Mahoning Township is underlain by two stray sands which are very local and variable. The Warren sands are represented by lenticular and variable sands between the Elizabeth and Speechley in South, West, and North Mahoning townships. In North Mahoning Township as many as five sands occur in this group. In West Mahoning Township the group in represented by only a few feet of sandy shale. The Second Balltown sand is very irregular in South Mahoning Township. In the same way, the Tiona sand shows as only a sandy phase in shale in Conemaugh, Blacklick, and Burrell townships. In the townships just mentioned the Kane group is probably represented by three sands encountered below the Third Bradford. The Elk group is represented in Armstrong and White townships by two sands found below the First Elk.

JEFFERSON COUNTY

In general sands which do not appear in the chart in some of the townships are irregular and sporadic in occurrence, though locally massive and possibly gas-producing. This is particularly true of the sands between the Snee and Speechley Stray.

In Rose Township the Berea appears as four distinct sandstones and in Warsaw Township as two distinct sandstones with a few feet of shale between. In Bell Township the Thirty-foot and Snee are joined, in places reaching a thickness of 120 feet.

The Warren group in this county may contain as many as five sands as in Bell Township or four as in Young and Perry townships. In Perry Township the Fifth Warren is very persistent, is gas producing, and has been mistaken locally for the Speechley. Where more than three Warren sands are present, they are all likely to be irregular, though usually one or more may produce gas.

The First and Second Balltown sands in Bell Township are represented by only a few feet of sandy shale which locally becomes sandstone. In Henderson Township the sands between the Allegheny and Sheffield though locally present are not well defined.

The Sheffield sand in Young Township is represented locally by several lenticular sands. In Perry Township it is in two divisions separated by 20 to 40 feet of shale. In Pine Creek Township it is in two or more divisions, separated from each other by a few feet of shale.

The Bradford group is locally sporadic and irregular in Bell Township. Locally the Tiona has been mistaken for the Speechley.

The Kane group is thin and sporadic in Bell Township, appearing as three sands which may locally become massive and gas producing. In Henderson Township the Second Kane is persistent, occurring 875 feet below the Speechley, and may contain gas. The other Kane sands in that township are thin and sporadic.

In a number of the townships the Elk group is represented by three lenticular sandstones. In many of the townships some drilling has penetrated below the lowest of the sands for which information is given in the chart, but not enough information is available to identify the sands or to describe them.

McKEAN COUNTY

A discussion of sands in McKean County should consider the Bradford field as a unit apart from the rest of the county. The productive sands of the Bradford field are not continuous with the sands at the same geologic horizon in other parts of the county. The Bradford sands thin out and disappear beyond the productive area of the Bradford pool and another sand which has been traced throughout the entire oil and gas region appears at approximately the same geologic horizon in other parts of McKean County.

In Wetmore Township the Bradford sands are not well developed and a few wells have been drilled through them.

Six or seven sands are present locally beneath the Sheffield. These sands are possible gas-producing horizons where they thicken.

In Hamilton and Corydon townships correlation of the sands proved difficult. No sands occurring above the Pink Rock have any great importance as oil and gas horizons. Four sands lie below the Pink Rock and the Speechley but they are extremely lenticular and variable in occurrence. Locally they may yield gas.

The productive oil and gas horizons in the Bradford field are in descending order: Chipmunk, Second Bradford, Third Bradford or *the* Bradford, Fourth or Windfall, Lewis Run, Fifth or Kane of the Bradford field, Kane, and Sixth or Haskell. The Bradford sand and those above it are of Chemung age. The sands below the Bradford are in the Portage.

The First Bradford sand of the Bradford District is in the approximate stratigraphic position of the Speechley sand of the main oil and gas field. The Chipmunk probably corresponds to one of the Balltown sands. The Second Bradford is very difficult to identify, but probably lies in the approximate position of the Second Bradford of the main oil and gas fields. The Third Bradford of the Bradford District and of the main oil and gas fields of Pennsylvania are of approximately the same geologic age. It is very doubtful, however, if the Bradford sand which is named from the type locality at Bradford extends far beyond the producing area of that field.

The Kane sands of the Bradford District correspond fairly well with the Kane sands of the type locality. They are probably not, however, continuous sands. The Haskell sand of the Bradford District is probably the equivalent of the First Elk of southwestern McKean County.

In the Bradford oil pool no production is found above the First Bradford; in other parts of McKean County gas is found in sands from the Hundred-foot to a sand in the Portage which lies below the Third Elk.

POTTER COUNTY

The sands of Potter County resemble those of the Bradford District of McKean County in geologic position. The Third Bradford or Richburg is the principal producing sand. The sands which lie above the Third Bradford are rarely productive.

The Speechley sand occurs at an average interval of 640 feet above the top of the Third Bradford. Where present it ranges from a few feet to 40 feet in thickness and averages 15 feet.

The top of the Tiona sand averages 540 feet above the top of the Third Bradford. The Tiona is extremely irregular in thickness and occurrence. Where present it ranges from a few feet to 50 feet thick and averages 15 feet.

The Chipmunk sand occurs at an average interval of 460 feet above the top of the Third Bradford. It probably corresponds to the First Balltown of the main oil and gas fields, is lacking in large areas, and where present, ranges from a few feet to 40 feet thick and averages 10 feet.

The Second Bradford sand occurs at an average interval of 340 feet above the top of the Third Bradford. The Second Bradford is a persistent sand which ranges from a few feet to 70 feet thick and averages 20 feet.

Two stray sands occur between the Second and Third Bradford.

The Third Bradford sand is one of the most important gas-producing sands in Potter County. It is persistent in occurrence, ranges from 10 to 60 feet and averages 20 feet thick.

The Lewis Run sand occurs at an average interval of 80 feet below the top of the Third Bradford. The Lewis Run is a very persistent sand ranging from a few feet to 80 feet in thickness and averages 40 feet.

The First Kane sand averages 115 feet below the top of the Third Bradford. The First Kane is a fairly persistent sand which ranges from a few feet to 100 feet in thickness and averaging 20 feet. It produces gas locally.

The Second Kane sand occurs at an average interval of 210 feet below the top of the Third Bradford. The Second Kane is not a persistent sand and occurs in only a few wells. Where present it ranges from a few feet to 30 feet in thickness and averages 15 feet.

The Third Kane sand averages 260 feet below the top of the Third Bradford. The Third Kane is not a persistent sand and where present ranges from a few feet to 60 feet in thickness and averages 15 feet.

The Elk group of three sands underlies the Third Kane. These sands are extremely variable in thickness and sporadic in occurrence. Locally they are massive and suitable reservoirs for gas.

VENANGO COUNTY

Although Venango County has been producing oil since 1859, and hundreds of wells have been drilled, there is yet need of more information to correlate the oil sands. The Venango oil sand group is a mass of sandstone deposits ranging from 300 to 380 feet thick separated by many local partings of shale. The First sand undoubtedly occurs at the horizon of the Hundred-foot sand of southwestern Pennsylvania.

The First sand is overlain by a very distinct soft shale group, 300 to 400 feet thick, in which occurs the Pithole grit which is undoubtedly of Berea age. The Mountain sands lie above the Pithole grit. They are massive and variable in thickness and are not producing horizons.

The Second sand of Venango County occurs approximately 150 feet below the top of the First sand. It is probably the stratigraphic equivalent of the Thirty-foot sand of southwestern Pennsylvania.

The Third sand lies at at an average interval of 240 feet below the top of the Hundred-foot and corresponds to the horizon of the Gordon Stray sand in southwestern Pennsylvania.

A fourth and a fifth sand underlie the Third Vanango oil sand but they have no economic importance.

The Venango group of oil sands is underlain by many hundred feet of shale. The Speechley, which lies at an average interval of 1,120 feet below the top of the First Venango sand, is the first sandstone which is persistent in occurrence and regular in thickness. It it characteristically a gas-producing sand.

In addition to the material contained in the chart, it may be noted that the Venango First sand shows a lower division in Richland, Rockland, and Cranberry townships. Locally this has been called the Red Valley sand.

WARREN COUNTY

Sands which are productive in Warren County are dry in other counties; sands which are massive and persistent in Warren County are thin and irregular in other counties.

Oil and gas production has come principally from the Glade, Clarendon, and Gartland sands. The majority of well logs from Warren County show only producing horizons and the Pink Rock. The extreme variability of the sands and the incomplete well records make correlation uncertain. The Clarendon is approximately in the geologic horizon of the Speechley of Venango County, and has been so-correlated in this discussion. The Glade sand is approximately the equivalent of the Speechley Stray of Venango County. The Gartland sand may correlate with the Allegheny sand of Venango and Forest counties.

The Third Bradford sand of the Bradford field appears to be absent in large areas in Warren County, occurring approximately 570 feet below the top of the Clarendon or Speechley sand.

The sands lying above the Glade or Speechley Stray have very little importance as oil and gas producers in this county and will not be discussed in detail. The average interval between the Venango First or Hundred-foot and the top of the Speechley sand is 1,250 feet.

The Hundred-foot or Venango First lies at very shallow depths in Warren County. Locally it is a suitable horizon for oil and gas.

The Berea in Warren County locally ranges from 10 to 40 feet thick, but it is not an oil- and gas-producing horizon.

WASHINGTON COUNTY

The Gas sands are not well developed in Centerville Borough and East Pike Run Township. One or more of the Salt sands is lacking in South Strabane Township.

In Canton Township the unconformity below the Pottsville brings the Big Injun sand from 100 to 150 feet nearer the Pittsburgh coal bed than it normally occurs.

The Gantz sand in West Finley Township and in several other townships is represented by only a few feet of shale.

The Thirty-foot sand in Donegal Township is represented usually by 20 to 30 feet of shaly sandstone.

A thin sand occurs below the Balltown at 2,900 feet below the top of the Big Injun sand in Hopewell Township.

WESTMORELAND COUNTY

Westmoreland County is primarily a gas-producing district. Some small oil pools have been developed. The Murrysville sand, which lies directly above the Hundred-foot, is the most important gas-producing sand in the county. It is usually a light-colored, open-grained, soft sandstone, which frequently contains both gas and water. The Hundred-foot, Fourth, Fifth, Bayard, Elizabeth, and Speechley sands are also important producers of gas.

The sands above the Murrysville are not important as gas producers Small quantities of gas have been found locally in the Squaw sand. The Berea is thin and sporadic in occurrence, and practically no production has come from it. In Lower Burrell and North Huntingdon townships the Berea sand is thin and likely to be confused with the Squaw sand.

The Gordon sand in the same township is underlain by five irregular sands. In Hempfield Township, the Elizabeth sand is underlain by three stray sands.

Fairfield, Derry, and Loyalhanna townships are outside the developed field and little drilling has been done in them. The small amount of drilling has revealed the presence of many sands. The Berea, Murrysville, and Hundred-foot are well represented. The Fifth, Bayard, and Elizabeth are represented in North Franklin Township. The sands from the Thirty-foot to the Bayard sand are represented by irregular sands in an interval of 350 feet of shale. In Lower Burrell Township five stray sands occur between the Elizabeth and Speechley.

Explanation of Charts

The left hand column indicates the sands in order from top to bottom.

The right hand margin is a scale for finding the distance of a sand above or below a key horizon marked O.

The logs as plotted show the average distance of the top and bottom of the sand above or below a definite reference horizon. The interval between the top and bottom lines of a sand therefore is not the thickness of the sand but the horizon at which the sand most generally occurs. A figure on the left of a columnar section gives the average thickness of the adjacent sands. Figures on the right are the minimum and maximum thickness of the sand.

Letters used in the columnar sections have the following significance:

O—Oil production
G—Gas production
OG—Oil and gas production
o—Sand is porous and might produce oil
g—Sand is porous and might produce gas
P—Sand is very persistent
p—Sand is generally found, though not universally
fp—Sand fairly persistent though lacking in many wells
np—Sand not persistent
ga—Sand generally absent, found only in a few wells
a—Sand is absent
c—Sand capable of holding oil or gas

The charts of composite well logs are contained in a pocket.

STATISTICS ON PETROLEUM, NATURAL GAS, AND ALLIED INDUSTRIES

By Forrest T. Moyer

SOURCES OF INFORMATION

The tables presented in this chapter are compiled from different sources and are as complete as can be made to December, 1932. In some instances when conflicting data are presented by various statistical bureaus, the differing sets of information are given and the reader may choose which he prefers.

The Mineral Resources of the United States, by the U. S. Geological Survey (1882-1923) and the U. S. Bureau of Mines (1924-1932), were followed wherever possible. All figures for which no references are given in the table footnotes are taken from the Mineral Resources volumes.

Publications of the Second Geological Survey of Pennsylvania, which cover the period from 1859 to 1890, were consulted to obtain data on the early history of the oil industry. The following reports are those relating especially to oil and gas:

Vol. I, Venango County
I-2, Well Records and Levels
I-3, and Atlas, Venango, Warren, Clarion, and Butler Oil Regions
I-4, Warren County
I-5, Seventh Report of the Oil and Gas Fields
J, The Oil Region
Vol. K, Greene and Washington counties
R and R2, McKean, Elk, and Forest counties
V and V2, North Butler and Clarion counties
Annual Report of 1885
Annual Report of 1886, Part 2
Grand Atlas, Division 3, Part 1

The Oil City Derrick's Handbook of Petroleum also covers very thoroughly the early days of the oil industry in Pennsylvania and New York. In addition to the day by day events in the oil fields from 1859 to 1900, the publications contain excellent statistics on development, production, and refining of oil.

Recent reports of the Bureau of Statistics of the Pennsylvania Department of Internal Affairs, entitled Productive Industries, Public Utilities, and Miscellaneous Statistics, are published either annually or biennially and contain important data on oil and gas. An old report, Petroleum, Its Production and Products in Pennsylvania, was published in 1893 by the Pennsylvania Department of Internal Affairs.

Other sources of information are: Petroleum in the United States and Possessions by Arnold and Kemnitzer, which contains varied and complete tables on oil, gas, and natural gasoline; Oil Fields in the United States by W. A. Ver Wiebe; American Petroleum, Supply and Demand, a report to the American Petroleum Institute; and the various U. S. Census Reports, especially Report on Petroleum by S. F. Peckham included in the 10th Census.

WELLS DRILLED FOR OIL AND GAS

During the early years of oil history, no attempt was made to gather statistics of the infant industry. From 1859 to 1875, no reliable data on the oil field operations are available. Several attempts were made to collect such information, but the results conflicted with each other.

As drilling was a tedious process in early days, development of the oil fields proceeded very slowly. Besides the Drake well, only one other was completed in 1859. On November 21, 1860, the Venango Spectator reported the names and locations of 74 producing wells with a combined daily production of 1,165 barrels. The Oil City Register, in May, 1862, gave a report of 75 producing wells, 62 wells that had formerly flowed and pumped and 358 drilling wells. Walter R. Johns in Petrolia stated that on January 1, 1869 there were 1,186 producing wells in the region. These wells were completed as follows: 1868—724; 1867—148; 1866—92; 1865—99; 1864—46; 1863—29; 1862—20; 1861—17; 1860—10; and 1859—1. In 1868 the number of wells completed was estimated as 991 which would give a dry hole list of 267.

In Volume J of the Second Geological Survey of Pennsylvania, Wrigley gives the total number of wells drilled in the oil region from 1859 to 1869 as 5,560. This would leave 4,374 wells that had been completed and abandoned as dry or unprofitable during the first ten years of the oil industry. Wrigley states, further, "that the number of wells drilled in succeeding years is: 1869—991; 1870—1,007; 1871—946; 1872—1,032; 1873—530; and 1874—433." Thus, the number of completed wells in Pennsylvania and New York from 1859 to January 1, 1875 would be 10,499 according to Wrigley's figures. The wells drilled during 1875 range from 1,188 to 2,398 as given by various reports.

The Second Geological Survey of Pennsylvania collected a complete set of statistics from 1876 to 1888. On August 1, 1887, J. F. Carll estimated that 55,000 wells had been completed in the Pennsylvania and New York fields up to that time.

The Mineral Resources of the United States, published by the Federal government carry complete figures on drilling activity from 1888 up to the present time.

The total number of wells completed in Pennsylvania and New York up to January 1, 1932 is given as 195,391. Dry holes number 31,474 or 16.1 per cent of the total number completed. Wells productive of oil are 159,105 or 81.4 per cent of the number of wells completed.

The approximate number of producing gas wells on Dec. 31, 1932 was 16,426 wells (Pa. Department of Internal Affairs).

The columns showing the number of wells drilled for gas in Pennsylvania are not complete and hence no totals are given in the following table.

Wells Drilled for Oil and Gas in Pennsylvania

Greene County[a] — Washington County[a] — Beaver County[a] — Allegheny County[a] — Bradford District[b] — Allegany County (New York) — Totals

Year — Oil — Gas — Dry — Total — Ave.[d] I. P.

Butler and Armstrong counties — Venango and Clarion counties — Southwest District[a] — Middle District[g]

Approximate number of producing oil wells Dec. 31 — Average daily yield per well (bbls.) — Number of oil wells abandoned — Number of wells drilled for gas: Gas, Dry, Total — Approximate number of producing gas wells Dec. 31 — Number of gas wells abandoned

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[a] Includes Allegheny, Beaver, Greene, Washington and miscellaneous counties in Pennsylvania [illegible] Elk, Forest and southwest McKean counties.

[b] [illegible] central McKean County and extends 5 or 6 miles into southeastern Cattaraugus County, N. Y.

[c] [illegible] Pennsylvania and New York.

[d] Average initial daily production per well (barrels).

[e] [illegible] figures are included in the totals columns.

[f] [illegible] gas wells are [illegible] in the productive well column.

[g] Data for lower district in Venango, Clarion, Butler, Armstrong and parts of Forest County. Wells in [illegible] only.

Bradford and Allegany (N. Y.) districts combined.

Total for all wells drilled previous to 1861.

Prior to and including 1906 the figures represent the average monthly number of producing wells in Pennsylvania and New York.

New York included with Pennsylvania.

Data from 11th Census Report.

Producing oil and gas wells combined. Figures from 11th Census Report, Vol. X.

Prior to and including [illegible] and for 1930 and 1931 figures combine New York with Pennsylvania.

Data from Oil and Gas Journal.

Data from Oil and Gas Journal. Tioga-Wayne District (gas) included. Figures for Tioga-Wayne District are: Oil 0, Gas [illegible], Dry [illegible], Total [illegible].

Average initial production for Allegany, N. Y. District wells only.

Petroleum in United States and Possessions by Arnold and Kemnitzer.

Annual Report, [illegible] Mineral Resources [illegible] Geological Survey.

Handbook of Petroleum, Oil City Derrick.

Production Statistics, Pennsylvania Department of Internal Affairs.

Petroleum Industry of Pennsylvania [illegible] Pennsylvania Department of Internal Affairs.

*New, abandoned, and producing oil wells, and average annual production per well in Pennsylvania by counties**

Year	Allegheny County				Armstrong County				Beaver County				Butler County			
	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)
1909	------	28	1,728	------	------	6	171	------	------	41	629	------	------	102	5,493	------
1910	------	54	1,743	------	------	2	178	------	------	20	613	------	------	216	5,351	------
1911	------	94	1,688	------	------	9	179	------	------	51	593	------	------	355	5,116	------
1912	------	74	1,664	------	------	17	170	------	------	17	609	------	------	106	5,268	------
1913	------	46	1,680	------	------	27	168	------	------	48	590	------	------	233	5,469	------
1914	------	35	1,729	------	------	10	185	------	------	8	663	------	------	65	5,605	------
1915	------	49	1,756	------	------	4	184	------	------	11	665	------	------	93	5,620	------
1916	------	71	1,750	------	------	3	188	------	------	7	694	------	------	443	5,341	------
1917	------	76	1,741	------	------	8	205	------	------	63	648	------	------	31	5,432	------
1918	------	86	1,713	------	------	9	196	------	------	27	652	------	------	177	5,295	------
1921	132	83	1,973	193.3	9	7	197	125.8	41	35	878	143.3	290	186	5,944	147.2
1922	145	148	1,970	205.7	6	6	197	125.8	83	69	882	132.2	312	246	6,040	136.7
1923	32	44	1,958	221.3	7	1	203	119.5	23	37	878	124.3	278	266	6,052	129.1
1924	37	90	1,905	244.5	3	4	202	105.7	26	25	879	104.6	186	216	6,022	122.2
1925	75	117	1,863	230.4	2	3	201	100.0	15	48	846	99.2	309	241	6,090	138.9
1926	36	85	1,835	243.5	1	5	197	100.1	44	28	865	97.5	177	190	6,105	114.6
1927	17	73	1,664	245.3	2	11	198	98.0	26	18	873	93.0	144	189	5,120	132.2
1928	145	112	1,695	286.7	3	21	180	101.8	10	16	869	88.8	369	495	5,909	109.5
1929	46	42	1,690	291.7	2	1	222	98.6	10	25	852	84.2	179	195	5,795	114.4
1930	22	37	1,687	303.3	5	2	323	106.6	7	53	807	81.9	382	526	5,581	108.6
1931	6	87	1,606	182.9	1	7	254	97.6	22	29	800	73.3	124	176	5,750	98.1

Year	Clarion County				Crawford County				Elk County				Forest County			
1909	------	19	1,598	------	------	7	500	------	------	3	1,063	------	------	72	1,512	------
1910	------	47	1,595	------	------	3	507	------	------	------	1,078	------	------	33	1,501	------
1911	------	42	1,792	------	------	6	616	------	------	9	1,116	------	------	40	1,633	------
1912	------	82	1,749	------	------	43	597	------	------	8	1,118	------	------	60	1,612	------
1913	------	136	1,751	------	------	76	568	------	------	4	1,150	------	------	95	1,662	------
1914	------	19	1,904	------	------	3	680	------	------	16	1,140	------	------	12	1,692	------
1915	------	36	1,965	------	------	3	704	------	------	3	1,148	------	------	97	1,609	------
1916	------	42	1,980	------	------	9	717	------	------	------	1,160	------	------	20	1,626	------
1917	------	29	2,008	------	------	5	734	------	------	90	1,081	------	------	25	1,621	------
1918	------	24	2,041	------	------	22	712	------	------	4	1,159	------	------	18	1,698	------
1921	163	117	2,437	94.3	46	------	1,036	46.0	13	3	1,138	102.3	24	51	1,628	58.9
1922	116	79	2,474	85.8	22	------	1,058	45.8	26	------	1,164	93.9	32	8	1,652	52.8
1923	97	57	2,514	83.9	93	70	1,081	54.6	10	------	1,174	86.6	178	84	1,746	50.0
1924	99	100	2,513	81.1	80	48	1,113	50.9	4	42	1,136	88.6	39	109	1,676	52.1
1925	99	69	2,543	84.0	178	4	1,287	41.8	4	96	1,044	89.6	19	17	1,678	78.1
1926	46	55	2,243	93.6	72	13	1,356	47.6	8	------	1,130	78.2	23	32	2,094	65.5
1927	53	------	2,699	70.5	67	69	1,354	55.6	14	16	1,068	80.7	200	222	2,220	57.6
1928	217	221	2,445	77.6	11	3	1,362	58.4	10	5	1,110	77.2	48	215	2,150	74.7
1929	140	67	2,539	77.6	18	71	1,309	76.9	10	2	1,307	70.4	19	44	1,684	60.6
1930	60	79	2,567	69.7	11	37	1,283	81.7	9	21	1,237	70.1	13	37	1,521	67.9
1931	35	48	2,554	66.3	2	4	1,281	82.1	19	1	1,255	67.0	12	16	1,517	61.5

New, abandoned, and producing oil wells, and average annual production per well in Pennsylvania by counties—Continued*

Year	Greene County				Jefferson County				Lawrence County				McKean County			
	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)
1909	-----	18	433	-----	-----	1	125	-----	-----	-----	9	-----	-----	135	14,571	-----
1910	-----	23	428	-----	-----	-----	126	-----	-----	-----	22	-----	-----	104	14,609	-----
1911	-----	14	484	-----	-----	2	131	-----	-----	-----	68	-----	-----	106	15,055	-----
1912	-----	19	490	-----	-----	1	135	-----	-----	3	178	-----	-----	373	14,970	-----
1913	-----	23	507	-----	-----	-----	142	-----	-----	1	918	-----	-----	528	15,055	-----
1914	-----	12	515	-----	-----	-----	152	-----	-----	2	1,139	-----	-----	125	15,376	-----
1915	-----	10	510	-----	-----	4	150	-----	-----	87	1.002	-----	-----	165	15,604	-----
1916	-----	7	519	-----	-----	-----	152	-----	-----	33	1,022	-----	-----	139	15,794	-----
1917	-----	10	522	-----	-----	4	155	-----	-----	58	944	-----	-----	183	15,985	-----
1918	-----	15	544	-----	-----	3	164	-----	-----	68	855	-----	-----	114	16,216	-----
1921	34	14	746	553.8	-----	9	163	81.0	37	2	370	85.8	650	261	20,612	112.2
1922	23	17	752	421.9	2	1	163	61.6	15	-----	385	82.7	1,071	801	20,882	118.1
1923	20	42	730	375.6	-----	-----	163	56.7	169	-----	554	51.7	1,174	3,466	18,590	134.0
1924	25	9	747	334.5	-----	1	162	52.1	-----	70	484	50.0	1,165	2,168	17,587	135.0
1925	34	18	763	397.0	-----	-----	162	52.6	8	3	489	46.0	1,308	1,633	17,262	149.1
1926	46	17	704	604.4	-----	27	558	37.9	-----	37	800	39.0	1,676	1,688	26,447	167.4
1927	23	14	742	499.5	-----	1	159	48.3	438	2	798	34.2	2,440	2,472	26,286	223.9
1928	19	3	750	304.8	-----	3	156	43.2	2	305	491	50.8	1,452	617	26,587	222.0
1929	20	6	770	355.5	1	-----	158	37.8	10	10	770	27.8	2,287	727	30,036	257.5
1930	15	27	770	317.5	1	1	157	39.4	4	2	806	38.5	2,791	2,305	29,851	310.5
1931	9	13	766	270.7	-----	-----	157	40.4	8	2	510	45.2	1,955	2,279	28,803	291.1

	Mercer County				Potter County				Tioga County				Venango County			
1909	-----	-----	267	-----	-----	1	159	-----	-----	-----	45	-----	-----	235	13,877	-----
1910	-----	-----	271	-----	-----	-----	159	-----	-----	4	41	-----	-----	226	13,989	-----
1911	-----	7	266	-----	-----	70	85	-----	-----	15	26	-----	-----	70	15,199	-----
1912	-----	1	276	-----	-----	7	78	-----	-----	19	7	-----	-----	281	15,552	-----
1913	-----	11	275	-----	-----	-----	92	-----	-----	-----	24	-----	-----	232	16,640	-----
1914	-----	11	278	-----	-----	-----	92	-----	-----	-----	24	-----	-----	209	18,104	-----
1915	-----	-----	326	-----	-----	-----	92	-----	-----	-----	24	-----	-----	516	17,895	-----
1916	-----	7	332	-----	-----	8	84	-----	-----	-----	24	-----	-----	734	17,735	-----
1917	-----	7	345	-----	-----	11	73	-----	-----	1	24	-----	-----	219	17,918	-----
1918	-----	34	229	-----	-----	-----	73	-----	-----	-----	29	-----	-----	103	18,117	-----
1921	5	28	325	45.5	-----	-----	271	50.2	2	-----	80	126.2	614	428	26,875	54.1
1922	6	7	324	40.0	-----	1	270	49.5	-----	-----	80	109.7	651	586	26,940	50.5
1923	40	-----	364	37.5	-----	-----	270	44.9	-----	-----	80	96.4	534	1,574	25,900	50.4
1924	9	10	363	37.2	-----	30	240	41.7	-----	-----	80	85.5	561	480	25,981	47.6
1925	7	1	369	37.4	15	3	252	46.4	-----	-----	80	73.9	1,041	556	26,466	44.7
1926	-----	-----	369	39.0	-----	-----	234	31.6	-----	64	16	152.6	2,035	2,114	26,933	43.8
1927	8	4	373	37.6	-----	1	233	29.4	-----	-----	-----	-----	811	763	27,304	44.5
1928	3	1	375	41.3	-----	3	251	35.3	-----	-----	-----	-----	1,815	2,278	26,017	44.1
1929	19	64	627	35.1	10	-----	261	11.9	-----	-----	-----	-----	1,264	1,278	26,180	49.3
1930	5	1	380	42.3	31	-----	292	20.7	-----	-----	-----	-----	452	475	26,076	43.4
1931	1	-----	381	37.9	10	71	231	26.9	-----	-----	-----	-----	2,015	2,148	25.942	41.8

New, abandoned, and producing oil wells, and average annual production per well in Pennsylvania by counties—Concluded

Year	Warren County				Washington County				Westmoreland County				Totals				
	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	New wells	Wells abandoned	Total wells producing	A.a.p.[1] per well (bbls.)	Percentage[2]
1909	------	350	6,308	------	------	48	1,822	------	------	------	------	------	------	1,066	50,310	------	------
1910	------	67	6,312	------	------	70	1,765	------	------	------	------	------	------	869	50,288	------	------
1911	------	60	6,906	------	------	131	1,792	------	------	------	------	------	------	1,081	52,745	------	------
1912	------	196	6,899	------	------	89	1,728	------	------	------	------	------	------	1,396	53,106	------	------
1913	------	248	6,941	------	------	98	1,662	------	------	------	------	------	------	1,806	55,294	------	------
1914	------	66	7,223	------	------	16	1,818	------	------	------	------	------	------	609	58,330	------	------
1915	------	66	7,339	------	------	35	1,850	------	------	------	------	------	------	1,179	58,443	------	------
1916	------	45	7,474	------	------	44	1,855	------	------	------	------	------	------	1,612	58,447	------	------
1917	------	94	7,470	------	------	79	1,830	------	------	------	------	------	------	944	58,766	------	------
1918	------	158	7,345	------	------	38	1,825	------	------	------	------	------	------	900	58,893	------	------
1921	317	286	7,053	48.6	43	22	2,005	264.9	------	------	1	150.0	2,421	1,532	73,732	98.3	90
1922	431	181	7,303	70.8	18	51	1,972	253.5	------	------	1	233.0	2,988	2,201	74,519	97.1	90
1923	291	579	7,015	71.8	17	51	1,983	245.0	------	------	1	215.0	2,963	6,271	71,211	99.3	90
1924	202	288	6,929	54.1	10	42	1,906	251.0	------	------	1	257.0	2,447	3,732	69,926	92.9	90
1925	86	173	6,842	43.1	14	41	1,879	250.4	------	------	1	186.0	3,214	3,023	70,117	96.6	90
1926	191	302	5,407	58.0	13	34	1,836	248.8	------	------	------	------	4,368	4,694	79,132	108.9	85
1927	256	621	6,009	57.1	48	73	1,821	250.3	------	------	------	------	4,547	4,549	78,806	126.7	85
1928	223	784	5,925	50.5	29	42	1,789	279.5	------	------	------	------	4,356	5,129	78,061	125.0	95
1929[a]	262	142	5,990	52.6	39	28	1,800	272.3	------	------	------	------	4,344	2,702	82,002	143.6	90
1930	195	306	5,950	53.3	27	13	1,819	262.2	------	------	------	------	4,022	3,922	81,107	160.4	90
1931	724	307	6,310	48.0	8	63	1,764	238.3	------	------	------	------	4,951	5,251	79,881	148.3	90

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[1] Average annual production per well (barrels).

[2] Number of new wells and abandoned wells are those reported by operators who produced the indicated percentage of total crude oil production in Pennsylvania and whose operations covered the entire territory.

[a] Fayette County in 1929 only, had one new well, no abandoned wells, and three producing wells with an average annual production per well of 573.6 barrels.

[*] Figures from 1909 to 1918 are from Mineral Resources of the United States by the U. S. Geological Survey. Figures from 1921 to 1930 are from Productive Industries by Pennsylvania Department of Internal Affairs. New well figures represent new producing oil wells only. No figures are available for 1919 and 1920.

*Summary of wells drilled and crude oil production in Pennsylvania and New York fields from 1859-1928, and during 1928 by districts**

District	Wells drilled, 1859–1928 [1]						Crude oil production in thousands of barrels			
							Period 1859–1928		Year 1928	
	Oil	Gas	Dry	Total	Ave. [2] I.P.	Dry	Total	Per cent	Total	Per cent
Bradford (Pa.-N. Y.) [3]	22,264	274	1,359	23,897	9.9	5.7	275,409	31.1	7,962	64.0
Venango-Clarion [4]	51,333	1,135	6,530	58,898	2.7	11.1	213,016	24.1	1,450	11.7
Southwest [5]	20,679	1,900	10,201	32,780	35.8	31.1	185,273	20.9	1,300	10.4
Butler-Armstrong [6]	25,763	478	8,251	34,492	11.8	23.9	95,286	10.8	750	6.0
Middle [7]	20,514	292	3,317	24,123	3.7	13.7	64,052	7.2	550	4.4
Allegany (N. Y.) [8]	12,324	341	1,575	14,240	2.3	11.1	52,042	5.9	437	3.5
Pennsylvania-New York	152,877	4,320	31,233	188,430			885,078	100.0	12,449	100.0
Average					9.9	16.6				

[1] Wildcat and proved areas.
[2] Average initial output of crude oil per well per day in barrels.
[3] Includes McKean, Potter, and Tioga counties in Pennsylvania and Cattaraugus County, New York.
[4] Includes Venango, Clarion, Erie, Crawford, Jefferson, and Clearfield counties.
[5] Includes Beaver, Allegheny, Westmoreland, Washington, Greene, and Fayette counties.
[6] Includes Butler, Armstrong, Mercer, Lawrence, Indiana, and Cambria counties.
[7] Includes Warren, Forest, Elk, Cameron, and Clinton counties.
[8] Includes Allegany and Steuben counties, New York.
* Petroleum in the United States, by Arnold and Kemnitzer.

*Number of producing gas wells by counties**

Counties	1931	1932
Allegheny	450	485
Armstrong	2,170	2,072
Beaver	92	48
Butler	503	432
Clarion	2,629	2,437
Clearfield	4	16
Clinton	100	0
Elk	1,048	1,178
Erie	60	53
Fayette	185	180
Forest	251	342
Greene	1,726	1,758
Indiana	441	434
Jefferson	1,656	1,588
Lawrence	7	7
McKean	1,882	1,823
Mercer	79	79
Potter	993	1,038
Tioga	2	8
Venango	915	590
Warren	366	227
Washington	919	918
Westmoreland	729	713
Total	17,207	16,426

* Productive Industries, Pa. Department of Internal Affairs.

DEEP WELLS

The Deemer or Irwin No. 1 well, listed No. 13 in the following table, is the deepest well in Pennsylvania, and the second deepest in the Appalachian Field. The depth of the well is 8,220+ feet. The deepest well in the Appalachian region is the United Fuel Gas Company's No. 4053, on the J. W. Hurzman Tract in Roane County, W. Va. This is the deepest cable tool drilled well in the world and reached a total depth of 9,104 feet, but secured no production. The world's deepest well is the Jardin 35 of the Penn Mex Fuel Company. It is located at Olamo, Vera Cruz, Mexico and has a total depth of 10,585 feet with no production.[1]

The correlations credited to the Pennsylvania Geological Survey were made by C. R. Fettke. They are based upon microscopic examinations of samples from the various wells.

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[1] Data on West Virginia and Mexico wells taken from the Oil Weekly, September 26, 1932, vol. 67, No. 2. The A.I.M.E. issue of September 1932, vol. 13, No. 309, gives the depth of the United Fuel Gas Company's No. 4053 well as 9,101 feet and its location at Frozen Camp, Jackson County, W. Va.

Deep well sections in Pennsylvania, Ohio, and West Virginia

No.	Elevation	Berea	Bradford or Benson	Onondaga	Oriskany	Clinton	Medina		Total depth	Remarks	Well finished in
1 [b]						2,260–2,320	Gray	2,470–2,493	3,572	Gas	
2 [a]	580				No sand 1,565		Red Gray	2,365–2,455 2,455–2,600	4,450		Trenton limestone
3 [a]	1,180				2,560–2,580?			3,446–3,635	3,735		Queenston shale
4 [a]					3,280–3,285				3.565	Dry	Salina shale
5 [a]	1,170				3,023–3,033			4,212–4,383	4,400		Queenston shale
6 [a]	1,200±				3,100–3,122?			4,347–4,536	4,619	Little gas	Queenston shale
7 [a]	990				3,205–3,220				3,225	Salt water	
8 [a]	1,641				4,344–4,349			5,591–5,782	5,818	Some gas	Queenston shale
9 [a]	1,200				4,527–4,535				5,252	Little gas	Salina shale
10 [a]	1,576				4,135–4,155		Red White	5,550–5,642 5,642–5,700	5,760	Dry	Queenston shale
10A [b]	1,585		1,120–1,198	4,065–4,135	4,135–4,155	5,320–5,560	Gray	5,642–5,760	5,760	Dry	
11 [a]	1,836				No sand 5,400		Red White	7,080–7,145 7,145–7,245	7,930	Dry	Queenston shale
11A [b]	1,841	110	2,108–2,148	5,308–5,476	5,476						
12 [a] [c]	1,474			3,913–3,930	3,930–3,980		Estimated	7,900	7,148	Dry	Vernon or Bloomsburg shale
13 [a]	1,350				7,235–7,265				8,220?	Dry	Salina shale
14 [b]		1,015			6,860–6,950				7,003	Dry	
15 [a]	1,122			6,786	6,840±				7,756	Gas	Salina shale
15A [b]	1,122	388– 475	2,470–2,488	6,786–6,807	6,807–7,185				7,753	Gas	
16 [a]	1,050				6,260–6,270				7,248	Salt water	
16A [b]	1,050	1,610–1,612	4,100–4,170	6,008–6,045	6,045–6,315				7,248	Dry	
17 [b]		300– 385				3,601–3,606			3,789		
18 [b]		442– 467				2,075–2,088			2,088		
19 [b]		1,010–1,033				3,709–3,747			3,805		
20 [b]	1,650			3,825–3,845	3,980–4,060				4,250	Dry	
21 [b]	2,020		1,456–1,495		4,312				4,900	Dry	
22 [b]	1,164	1,512–1,540	4,166–4,167	7,363–7,386					7,386	Dry	
23 [b]	1,201	1,000–1,025	3,420–3,428	6,955–7,018	7,018–7,037				7,579	Dry	
24 [b]	1,256	905– 906			4,499–4,595				4,597	Oil	
25 [b]		2,093–2,105		4,945–5,035	5,035–5,045				5,595	Dry	
26 [b]		2,123–2,140			3,675–3,685	4,500–4,540			4,750		
27 [b]					2,750–2,760				2,770	Dry	
28 [b]		1,515–1,565	3,500–3,520						5.575	Dry	

a. Data of the Pennsylvania Geological Survey by C. R. Fettke, Pittsburgh, Pennsylvania.
b. Data from "Deep Well Drilling in the Eastern Field," by J. F. Robinson, Oil and Gas Journal, May 17, 1928.
c. Salina reached at 4,261.

1. City of Erie, Erie County, Pennsylvania.
2. Presque Isle, Erie County, Pa., Presque Isle Natural Gas Company.
3. No. 381, Pa. Gas Company, Washington Township, Erie County, Pa.
4. No. 3219, United Natural Gas Company, Rockdale Township, Crawford County, Pa.
5. No. 3508, United Natural Gas Company, Vernon Township, Crawford County, Pa.
6. R. C. Jamison 1, South Shenango Township, Crawford County, Pa.
7. Clyde Fisher well (near Osgood), Sugar Grove Township, Mercer County, Pa.
8. No. 1, Fidelity Petroleum Corp., Tidioute, Triumph Township, Warren County, Pa.
9. No. 134, Collins & Richards, Kingsley Township, Forest County, Pa.

10 & 10A. No. 1 Bradford Deep Well Company (Derrick City well), Foster Township, McKean County, Pa.
11 & 11A. No. 3737, United Natural Gas Company, Highland Township, Elk County, Pa.
12. Shoemaker No. 1, Lycoming Natural Gas Corporation, Lawrence Township, Tioga County, Pa.
13. Irvin No. 1, F. C. Deemer, (Deemer well) Gaskill Township, Jefferson County, Pa.
14. Phillips Gas, Indiana County, Pa.
15 & 15A. No. 1842, Peoples Natural Gas Company (McCance well), Ligonier Township, Westmoreland County, Pa.
16 & 16A. No. 770, Peoples Natural Gas Company (McDonald well), Robinson Township, Washington County, Pa.
17. United Natural Gas Company, Akron, Summit County, Ohio.
18. Federal Fuel & Gas Company, Lancaster County, Ohio.
19. Zanesville Oil & Gas Company, Muskingum County, Ohio.
20. Parsons Pulp Company, Tucker County, West Virginia.
21. Hope Natural Gas Company, Preston County, West Virginia.
22. Hope Natural Gas Company, Harrison County, West Virginia.
23. Hope Natural Gas Company, Marion County, West Virginia.
24. Hope Natural Gas Company, Wood County, West Virginia.
25. Edwards Oil Company, Kanawha County, West Virginia.
26. Nixon Oil and Gas Company, Cabell County, West Virginia.
27. Nixon Oil and Gas Company, Cabell County, West Virginia.
28. Forest Oil Company, Allegheny County, Pa.

*Approximate investment in the drilling of wells in Pennsylvania, 1859-1928**

Class of drilling	Number of wells	Drilling investment (cost)	
		Total amount	Per well drilled
Wildcat wells	8,696	$ 106,873,840	$12,290
Proved-area wells	159,494	1,192,217,650	7,475
Total	168,190	$1,299,091,490	
Average			$ 7,724

* Petroleum in the United States, by Arnold and Kemnitzer.

AVERAGE DEPTH OF PRODUCTIVE WELLS

The estimated average depth of productive wells in various oil and gas districts of Pennsylvania, is as follows:* Bradford district, 1,230 feet; Middle district, 710 feet; Venango-Clarion district, 750 feet; Butler-Armstrong district, 1,505 feet; and Southwest district, 2,175 feet. The estimated average depth for the State, though not particularly significant is 1,344 feet.

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*Petroleum in the United States and Possessions, by Arnold and Kemnitzer.

DEPTH, COST, NUMBER OF WELLS DRILLED, AND PRODUCTION PER ACRE

*Wells—Number drilled, depth and cost, and acreage productive in Pennsylvania 1859-1928**

Wildcat Areas [1]

Drilled					Present status		Depth (feet)		Cost
Oil	Gas	Dry	Total	Per cent dry	Producing[2]	Abandoned[3]	Range	Average	Average
178	120	8,398	8,696	96.8	(See below)		100–7,826	1,785	$12,290

Proved Areas

Drilled					Present status		Depth (feet)		Cost
Oil	Gas	Dry	Total	Per cent dry	Producing[2]	Abandoned[3]	Range	Average	Average
134,575	3,859	21,060	159,494	13.2	(See below)		450–3,950	1,375	$7,475

Wildcat and Proved Areas Combined

Drilled					Present status		Depth (feet)		Cost
Oil	Gas	Dry	Total	Per cent dry	Producing[2]	Abandoned[3]	Range	Average	Average
134,753	3,979	29,458	168,190	16.9	78,600	56,153	100–7,826	1,396	$7.724

Wildcat and Proved Areas Combined (continued)

Acreage productive January 1, 1929		Crude oil production (barrels)			Unit comparisons		
					Oil produced per		
			Maximum		Wells drilled		
Oil	Gas	Total 1859-1928	Year	Amount	Oil [4]	Total [5]	Proved acre
869,000	950,820	805,963,000	1891	31,424,000	5,981	4,792	927

[1] Areas at least a mile outside proved production.
[2] Producing oil wells, December 31, 1928.
[3] Abandoned and shut-in wells, December 31, 1928.
[4] Per oil well drilled.
[5] Per total wells drilled.
[6] Proved oil lands.
* Petroleum in the United States by Arnold and Kemnitzer.

DEPTH AND ROCK PRESSURE OF NATURAL GAS WELLS

The following table shows the range of rock pressure and depth of natural gas wells in the various counties in Pennsylvania during the period from 1906 to and including 1917. The greater depth limit from 1917 on has probably been considerably increased in all the counties: for example, in Westmoreland County where the McCance well now produces gas at 6,840 feet and has a total depth of 7,756 feet; in Tioga County where gas is now produced as deep as 4,280 feet, the deepest well being 7,148 feet, and in Potter County where the lower productive limit has been extended down to 4,925 feet. Discoveries of new gas fields and new producing horizons have in some counties considerably raised the rock pressure figures. An average rock pressure in Farmington Township, Tioga County during 1931 would be between 1,500 and 1,600 pounds. In Potter County, the discovery of the Hebron pool would place the upper limit of rock pressure at about 2,100 pounds.

Range of depth and rock pressure of natural gas wells in Pennsylvania by counties

Year	Allegheny (Pounds)	Armstrong (Pounds)	Beaver (Pounds)	Butler (Pounds)	Clarion (Pounds)	Crawford-Erie (Pounds)	Elk (Pounds)
1906 ------	1– 380	7– 900	------------	22– 700	6– 450	25– 100	50– 990
1907 ------	7– 400	6– 800	4	15– 625	3– 700	10– 200	49– 960
1908 ------	1– 350	2– 600	------------	15– 550	15– 500	– 100	50– 940
1909 ------	10– 600	25– 900	4– 600	30– 600	8– 800	1– 85	50– 990
1910 ------	10– 600	3– 800	4– 75	6– 700	25– 900	0– 85	50– 990
1911 ------	10– 800	3– 435	------------	4– 800	5– 900	0– 100	40– 900
1912 ------	10– 500	5– 900	30– 70	2– 700	1– 900	2– 100	60– 840
1913 ------	15–1,000[a]	1– 500	30– 510	4– 850	2– 800	10– 50	50– 980[a]
1914 ------	10– 700	1– 800	40– 560	8– 450	0– 700	5– 40	60–1,000[a]
1915 ------	10– 900	3– 500	30– 200	8– 600[a]	2– 850[a]	25– 30	60– 900[a]
1916 ------	10– 700	3– 700	10– 125	5– 800[a]	10– 700	----------	50– 800
1917 ------	8–1,600	2– 500	25– 125	2– 800	4– 700	----------	6–1,200
Depth	Feet	Feet	Feet	Feet	Feet	Feet	Feet
	750–3,500	575–3,600	700–2,000	700–3,384	506–3,100	550–1,200 300–1,600	500–3,200

Year	Fayette–Somerset (Pounds)	Fayette–Cambria (Pounds)	Forest (Pounds)	Greene (Pounds)	Indiana (Pounds)	Jefferson (Pounds)	Lawrence–Mercer (Pounds)
1906 -	28– 300	--------------	6– 90	80– 350	-------------	70– 800	30– 150
1907 -	------------	100– 550	75– 250	80–1,200	-------------	200– 500	------------
1908 -	------------	200– 550	85– 160	70– 350	-------------	325– 760	------------
1909 -	------------	100– 700	15– 145	50– 500	-------------	10– 635	40
1910 -	------------	100– 650	10– 850	40– 400	-------------	100– 700	------------
1911 -	------------	40– 600	6– 150	40– 900	-------------	60–1,200	160– 250
1912 -	------------	35– 700	5– 800	60– 575	-------------	90–1,000	190
1913 -	------------	35– 700	17– 700	39– 750	600	100– 960	51– 300
1914 -	------------	35– 550	25– 600	50– 650	500	15–1,100[a]	26– 450
1915 -	------------	– 600	3– 700	30– 600	300	5– 800	150– 450
1916 -	------------	400– 570	21– 900[a]	30– 700[a]	-------------	10– 740	230– 280
1917 -	------------	300– 400	5– 600	28– 540	-------------	10– 850	60– 280
Depth	Feet	Feet	Feet	Feet	Feet	Feet	Feet
	1,700–2,660	1,200–2,772 2,350–2,500	370–3,165	680–3,600	1,100–1,860	700–3,360	650–850 800–1,150

Range of depth and rock pressure of natural gas wells in Pennsylvania by counties—Continued

Year	McKean (Pounds)	Potter (Pounds)	Tioga (Pounds)	Venango (Pounds)	Warren (Pounds)	Washington (Pounds)	Westmoreland (Pounds)
1906	18– 800	125– 400	----	90– 200	20– 100	30–1,300	80– 100
1907	20– 450	40– 360	350	70– 150	10– 60	15– 100	– 25
1908	15– 500	100– 460	300	40– 400	14– 250	5– 400	10– 30
1909	30– 600	60– 500	250	20– 250	20– 50	12– 500	50– 180
1910	6– 600	50– 300	300	10– 85	10– 190	5– 800	10– 25
1911	5– 850	35– 500	13– 350	10– 500	3– 200	5– 600	60– 250
1912	1– 950	10– 360	----	15– 200	10– 350	5– 550	15– 20
1913	3– 800	20– 600	----	10– 200	5– 280	5– 400	6–1,000[a]
1914	2– 525	50– 385	----	24– 450	5– 300	5– 400	16–1,000[a]
1915	7– 900	20– 300	----	15– 400	8– 80	2– 400	1–1,000[a]
1916	4– 800[a]	70– 250	----	10– 600	0– 300	10– 500	3– 900[a]
1917	2– 700	30– 150	----	17– 200	2– 400	8– 500	2– 800
Depth	Feet	Feet	Feet	Feet	Feet	Feet	Feet
	750–3,000	750–2,400	700–1,400	350–2,700	500–3,290	606–3,500	1,200–3,800

[a] New well.

CRUDE OIL PRODUCTION

DIVISIONS OF OIL REGION

The oil region of Pennsylvania and New York extends as a belt from the southwest corner of Pennsylvania in a northeast direction into southeast Allegany County, N. Y. The Pennsylvania counties included in the oil region are Greene, Washington, Beaver, Allegheny, Lawrence, Mercer, Crawford, Butler, Armstrong, Jefferson, Clarion, Venango, Forest, Elk, Warren, McKean, and Potter. Oil is produced in other counties but only in small quantities from isolated pools. The New York counties are Allegany and Cattaraugus, which has the northern portion of the Bradford field.

The oil region is divided as follows: into the northern, middle and southern fields.

NORTHERN OIL FIELD

Allegany (N. Y.) district: Lies in southeastern Allegany County, N. Y.

Bradford district: Includes the northern and central portions of McKean County, Pennsylvania and extends 5 or 6 miles into southeastern Cattaraugus County, N. Y. It is estimated in Mineral Resources that 8¼ to 8½ per cent of the Bradford production comes from Cattaraugus County, N. Y. The pools included are the Bradford, Kinzua, Windfall Run, Smethport and the small pools of Potter and Tioga counties. The Bradford district combined with the Allegany (N. Y.) district comprises the Northern Oil Field and the production from this field is the so-called "black sand" production of the Second Pennsylvania Geological Survey.

Tioga County district: Production from Tioga and Potter counties.

MIDDLE OIL FIELD

Includes southern and western McKean County, nearly all of Warren County, northwestern Elk County and northern and eastern Forest County. Pools in the field are Clarendon, Warren, North Warren, Balltown, Cooper and Sheffield, Glade Run, Stoneham, Tiona, Grand Valley, Sugar Run, Dew Drop, Wardwell, Kane, Elk and others. The production of the Middle Oil Field combined with that of the Lower or Southern Field comprise the "white sand" production of the Second Pennsylvania Geological Survey. Exceptions are the Kane and Elk pools which are black sand pools, but are included in the Middle Oil Field. The field is divided into three districts: Clarendon and Warren district, Tiona district, Middle district.

SOUTHERN OIL FIELD

Includes the remaining area of the oil region in Pennsylvania and is divided into the following:

Lower district: Beginning with western Forest and southwestern Warren, the district extends over Crawford, Venango, Armstrong and all of Butler counties. The major pools included are Tidioute and Titusville, Oil Creek, Tarkill, Bullion, Fagundus, Pithole and Cashup, Sugar Creek, Reno, Bradys Bend, Baldridge, Butler Cross Belt, Scrubgrass, Gas City, Enterprise, Church Run, and other pools.

Franklin district: Includes the oil pool in the immediate vicinity of Franklin, Venango County more specifically the area between the Allegheny River and French Creek at Franklin. This district is separated from the Lower District because of the unusual quality of lubricating oil produced.

Beaver County district: Includes Beaver and Lawrence counties. Pools are Smiths Ferry, Ohioville, Slippery Rock, Freedom and others.

Allegheny County district: Includes Allegheny County and the part of Washington County which contains the McDonald pool. Pools are Shannopin, Brush Creek, Milltown, McDonald, Gibsonia and others.

Washington County district: Includes all of Washington County with the exception of the McDonald pool.

Greene County district: Consists of all of Greene County. Pools included in the district are Blackshire, Mt. Morris, Fonner, Bristoria, Dunkard Creek, Nineveh and others.

The table showing production by districts is not complete, and hence, no totals for the districts are given. Moreover, the various statistical sources used different geographical divisions and it would be impossible to separate the production into districts common to all the sources of information. In the early volumes of Mineral Resources, the districts used changed frequently. In order to overcome this difficulty, it was necessary to combine some of the smaller districts into larger ones that would be common throughout a period of years.

GENERAL PRODUCTION STATISTICS

The total yearly production during the early history of the oil industry varies greatly according to the source of information. Prof. Wrigley in Volume J of the Second Geological Survey of Pennsylvania gives the production in 1859 as 3,200 barrels and in 1860 as 650,000 barrels. Mr. Carll of the same Survey in a later report states that the production in 1859 was 2,000 barrels and in 1860 was 200,000 barrels. Prof. S. F. Peckham in the 10th Census Report gives the production in 1859 as 2,000 barrels and in 1860 as 500,000 barrels. The Mineral Resources by the U. S. Geological Survey use the figures of Prof. Peckham.

The statistics on the production of petroleum by counties from 1921 to 1930 were collected by the Bureau of Statistics of the Pennsylvania Department of Internal Affairs. As will be noted, for the years 1923-1926 there is considerable difference in total Pennsylvania production as given by the Pennsylvania Bureau of Statistics and that given by the Mineral Resources publications of the U. S. Bureau of Mines. This difference occurs chiefly in the production listed for McKean County or more specifically the Bradford pool. The cause of this discrepancy appears to be in the number of operators reporting to each bureau, the U. S. Bureau of Mines having more reports on production than the Pennsylvania Bureau of Statistics.

In separating the production of Pennsylvania from that of New York, it was found that New York production was small up to 1876 and can be disregarded until that time. The Bradford pool production really started in 1876 and as this pool extends into New York it marked the beginning of important production from New York. The Allegany (N. Y.) district was not discovered until 1880. In the Mineral Resources volumes, Pennsylvania production is separated from that of New York in all the years except 1880, 1881, 1888 and 1890. By using Pennsylvania production figures from other sources for these years, the total production of crude oil in Pennsylvania, from 1859 to January 1, 1932 is 850,131,000 barrels. During this period the total production of the United States is 13,997,012,000 barrels, of which Pennsylvania can be credited with 6.1 per cent. The total value of the United States crude oil production from 1859 up to January

1, 1932 is estimated at $18,198,724,000. Total value of crude oil produced in Pennsylvania is $1,396,849,000 or 7.7 per cent of the total United States value of production.

Preliminary figures for crude oil production in Pennsylvania during 1932 are 12,403,000 barrels (Mineral Resources).

PRICE PER BARREL

Previous to Col. Drake's well, petroleum collected from surface springs and salt wells found a ready market at prices ranging from $0.75 to $2.00 a gallon. The discovery well broke the market and the first product of Drake's well sold for $0.50 a gallon. The price generally accepted for the remainder of 1859 is $20.00 per barrel, which is the highest price commanded by petroleum in Pennsylvania.

In 1861, with the discovery of flowing wells in the Oil Creek Valley, the price per barrel rapidly declined from $1.75 in January to $0.10 in October, the low price continuing until January 1862. During this period some sales were reported as $0.05 a barrel. In conjunction with the greatly increased production, the outbreak of the Civil War and the ensuing panic undoubtedly helped bring about the low price of oil. The average price for 1861 as given by Mineral Resources was $0.59 a barrel. This is the record low yearly average price for petroleum in Pennsylvania.

Previous to 1872, there was considerable variation in the size of the barrel which ranged from 40 to 50 gallons. On August 20, 1872, the leading oil companies made an agreement to sell oil only by the gallon, with an allowance of two gallons on the gauge of each and every 40 gallons in favor of the buyer. This virtually established 42 gallons as the standard measurement for a barrel of crude oil, which standard exists to this day.

Previous to 1875, the quotations per barrel are given for points along Oil Creek, and they hardly represent the value at the wells. From 1875, the adoption of pipe line certificates improved the conditions for the trading of oil and the oil exchange quotations show very closely the value of the oil at the wells. Previous to 1895 the price per barrel does not include the high priced oil of the Franklin district, but an average yearly price for Pennsylvania grade petroleum. From 1895 on the price of Franklin oil is included in the yearly average.

Yearly and total crude oil production in Pennsylvania by districts from 1859 to 1885 inclusive.

(Units of thousands of barrels)*

Year	Oil Creek [1]	Central [2] Allegheny	Tidioute [3] and Fagundus	Beaver [4] and Smiths Ferry	Pithole [5] and Cashup	Butler [6] and Armstrong	Clarion [7]	Bradford [8]	Warren [9] and Forest	Bullion [10]	Total
1859	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	2
1860	120	75	5	-----	-----	-----	-----	-----	-----	-----	200
1861	1,870	170	50	20	-----	-----	-----	-----	-----	-----	2,110
1862	2,860	125	40	30	-----	-----	-----	-----	-----	-----	3,055
1863	2,480	80	30	20	-----	-----	-----	-----	-----	-----	2,610
1864	2,000	85	30	15	-----	-----	-----	-----	-----	-----	2,130
1865	1,600	100	100	20	900	1	-----	-----	-----	-----	2,721
1866	2,000	200	600	25	900	5	2	-----	-----	-----	3,732
1867	1,950	200	850	20	550	8	5	-----	-----	-----	3,583
1868	2,300	300	750	20	300	25	20	1	-----	-----	3,716
1869	3,000	350	800	20	100	45	35	1	-----	-----	4,351
1870	2,900	400	1,000	20	75	900	75	1	-----	-----	5,371
1871	2,200	800	1,000	20	100	1,100	310	1	-----	-----	5,531
1872	1,700	800	1,100	25	200	1,700	830	2	-----	-----	6,357
1873	1,200	800	900	30	100	4,400	2,500	2	-----	-----	9,932
1874	800	500	400	30	50	5,200	3,900	3	-----	-----	10,883
1875	550	400	350	35	40	4,650	2,750	25	1	-----	8,801
1876	650	350	350	35	30	4,700	2,400	380	55	65	9,015
1877	800	450	310	62	15	5,500	3,000	1,450	150	1,306	13,043
1878	750	350	300	92	10	4,500	2,250	6,500	110	505	15,367
1879	500	250	250	82	5	2,800	1,400	14,200	50	290	19,827
1880	400	170	230	103	3	1,700	900	22,300	90	147	26,043
1881	350	150	220	100	-----	1,400	850	23,000	440	128	26,638
1882	280	155	195	80	-----	1,300	600	18,000	3,300	100	24,010
Total	33,262	7,260	9,860	904	3,378	39,934	21,827	85,866	4,196	2,541	209,028

Year	Venango [11] and Butler (proper)	Baldridge [12] and Thorn Creek	Cogley Run [13]	Warren [14] and Clarendon	Cherry [14] Grove	Cooper [14]	Balltown [14]	Wardwell [14]	Bradford [8]	Total
1882 [a]	118,966	-----	-----	1,818	2,345	30	3	-----	85,866	209,028
1883	2,700	-----	-----	873	756	1,096	776	-----	13,400	19,600
1884	2,687	963	-----	1,221	265	1,005	808	701	12,000	19,650
1885	2,786	1,813	701	1,426	136	341	348	149	10,600	18,300
Total	127,139	2,776	701	5,338	3,502	2,472	1,935	850	121,866	266,578

[1] Includes Oil Creek Valley and borders, Cherry Run, Keech Farm, West Pithole, Pleasantville and surroundings, Enterprise, Shamburg, Octave, Titusville and Church Run pools in north central Venango County.

[2] Includes Allegheny River from Scrubgrass to East Hickory including East Sandy, Bully Hill, Franklin, Reno, Slate Run, Walnut Bend, Henrys' Bend, and mouth of West Hickory pools, in east and west central and central Venango County,

[3] Includes Tidioute, Economy, Dennis Run, Triumph, New London, Colorado, and Fagundus pools in western Forest and southwestern Warren counties.

[4] Includes Smith's Ferry, Ohioville and Slippery Rock pools in Beaver and Lawrence counties.

[5] Includes Holmden, Morey, Ball and Rooker farms, and the Cashup pool in Northeastern Venango County,

[6] Embracing all the oil territory in these two counties.

[7] Includes Foxburg, Richey Run, Emlenton, St. Petersburg, Edenburg, and Shippensville pools.

[8] The Northern Oil Fields of McKean County, Pennsylvania and Cattaraugus County, New York.

[9] Includes Warren, Stoneham, Clarendon, Cherry Grove, and Sheffield pools in Warren County and Balltown, Blue Jay, and Cooper districts in Forest County.

[10] Includes Bullion Run and its surroundings in southwestern Venango County,

[11] Includes the following districts—Oil Creek, Central Allegheny, Tidioute and Fagundus, Beaver and Smith's Ferry, Pithole and Cashup, Butler and Armstrong, Clarion and Bullion.

[12] A new pool in central Butler County.

[13] A new pool in northwestern Clarion County,

[14] Since 1881, the production of the Warren and Forest District has been subdivided into the following districts; Warren and Clarendon, Cherry Grove, Cooper, Balltown and Wardwell.

[a] Figures opposite 1882 indicate the total production up to the end of 1882.

[*] Reference:—Statistical Chart No. 1, Annual Report 1886, part 2, Second Pennsylvania Geological Survey.

Crude oil production in Pennsylvania by counties and districts

Year	Allegheny[1] County (bbls.)	Armstrong County (bbls.)	Beaver[2] County (bbls.)	Bradford[3] District (bbls.)	Butler County (bbls.)	Clarendon[4] and Warren Dist. (bbls.)
1875	---	---	---	36,000*[d]	---	---
1876	---	---	---	382,768*	---	---
1877	---	---	---	1,468,451*	---	---
1878	---	---	---	6,197,746*	---	---
1879	---	---	---	14,084,120*	---	---
1880	---	---	---	20,138,091*	---	---
1881	---	---	---	25,846,261*	---	---
1882	---	---	---	18,625,980*	---	---
1883	---	---	---	13,436,426*	---	---
1884	---	---	---	12,096,950*	---	---
1885	---	---	---	8,441,501	---	---
1886	---	---	---	7,043,617	---	---
1887	---	---	---	7,563,432	---	---
1888	---	---	---	6,284,375[c]	---	---
1889	541,092	---	631,736	7,158,363[c]	---	---
1890	2,707,039†	---	1,448,139†	6,269,727†	---	266,452†
1891	10,317,258	---	972,223	5,452,418	---	360,227
1892	10,196,856	---	652,372	4,291,061	---	272,523
1893	5,488,792	---	486,093	3,502,136	---	327,680
1894	4,559,342	---	469,410	3,359,835	---	338,570
1895	3,864,111	---	474,676	3,244,808	---	369,747
1896	4,380,007	---	553,000	3,604,771	---	385,294
1897	2,958,540	---	320,326	3,904,230	---	378,075
1898	2,301,651	---	222,976	3,444,299	---	414,212
1899	1,988,754	---	233,304	3,206,845	---	414,352
1900	1,706,886	---	417,619	3,022,493	---	383,493
1901	1,440,967	---	800,688	2,757,603	---	404,433
1902	1,376,212	---	529,934	2,506,981	---	468,420
1903	1,187,496	---	444,097	2,326,413	---	514,675
1904	1,008,977	---	359,282	2,187,883	---	520,925
1905	918,224	---	313,323	2,115,225	---	433,667
1906	902,253	---	261,144	1,922,501	---	458,533
1921[a]	598,480	24,807	125,795	---	874,878	---
1922	574,552	24,788	117,914	---	825,366	---
1923	561,398	24,266	109,140	---	781,402	---
1924	467,265	21,350	91,973	---	735,900	---
1925	453,648	20,093	83,908	---	846,151	---
1926	422,797	19,718	84,296	---	689,782	---
1927	406,771	19,420	81,198	---	677,004	---
1928	375,062	18,319	77,153	---	646,942	---
1929[b]	349,497	19,564	71,744	---	679,752	---
1930	326,050	34,435	66,112	---	606,211	---
1931	293,685	24,788	58,606	---	564,330	---

Year	Clarion County (bbls.)	Crawford County (bbls.)	Elk County (bbls.)	Forest County (bbls.)	Franklin[5] District (bbls.)	Greene County (bbls.)
1888	---	---	---	---	---	93,034
1889	---	---	---	---	65,276	392,912
1890	---	---	---	---	---	956,030†
1891	---	---	---	---	65,185	341,813
1892	---	---	---	---	58,459	102,108
1893	---	---	---	---	66,278	74,377
1894	---	---	---	---	57,070	64,176
1895	---	---	---	---	48,711	116,931
1896	---	---	---	---	49,329	94,796
1897	---	---	---	---	48,880	258,065
1898	---	---	---	---	56,090	325,177
1899	---	---	---	---	61,085	381,483
1900	---	---	---	---	59,036	558,379
1901	---	---	---	---	55,162	771,708
1902	---	---	---	---	50,555	721,574
1903	---	---	---	---	48,209	567,999
1904	---	---	---	---	48,499	541,356
1905	---	---	---	---	44,118	473,810
1906	---	---	---	---	44,412	390,505
1921[a]	230,044	48,298	116,432	96,033	---	413,163
1922	212,206	48,406	109,244	87,226	---	317,343
1923	210,914	59,024	101,642	82,707	---	274,229
1924	203,685	56,613	100,701	87,369	---	249,871
1925	208,807	57,637	93,546	131,162	---	302,938
1926	209,965	64,523	88,419	137,078	---	439,576
1927	190,365	75,235	86,213	127,814	---	370,612
1928	189,740	79,482	85,643	160,577	---	228,199
1929[b]	195,665	99,614	92,058	102,017	---	276,263
1930	178,839	104,759	86,736	103,271	---	244,495
1931	169,345	105.237	84.136	93,290	---	207.349

Crude oil production in Pennsylvania by counties and districts—Continued

Year	Jefferson County (bbls.)	Lawrence County (bbls.)	Lower [6] District (bbls.)	McKean County (bbls.)	Mercer County (bbls.)	Middle [4] District (bbls.)
1885 ------	------	------	7,245,911	------	------	2,430,618
1886 ------	------	------	9,857,059	------	------	3,908,197
1887 ------	------	------	9,167,819	------	------	1,115,498
1888 ------	------	------	5,715,452	------	------	2,069,616
1889 ------	------	------	6,243,522	------	------	2,606,389
1890 ------	------	------	8,919,942†	------	------	2,103,001†
1891 ------	------	------	9,091,970	------	------	1,735,560
1892 ------	------	------	7,738,878	------	------	1,273,421
1893 ------	------	------	5,867,522	------	------	1,303,767
1894 ------	------	------	6,259,723	------	------	1,215,628
1895 ------	------	------	7,215,356	------	------	1,170,392
1896 ------	------	------	7,539,807	------	------	956,390
1897 ------	------	------	6,825,599	------	------	1,329,448
1898 ------	------	------	5,500,433	------	------	932,000
1899 ------	------	------	5,080,182	------	------	528,440
1900 ------	------	------	5,364,398	------	------	452,136
1901 ------	------	------	4,855,049	------	------	176,185
1902 ------	------	------	4,754,979	------	------	162,762
1903 ------	------	------	4,794,520	------	------	------
1904 ------	------	------	4,859,954	------	------	------
1905 ------	------	------	4,577,775	------	------	------
1906 ------	------	------	4,735,004	------	------	------
1921 [a] ----	13,210	31,736	------	2,311,662	14,795	------
1922 ------	10,036	31,825	------	2,466,723	12,954	------
1923 ------	9,237	28,654	------	2,490,696	13,643	------
1924 ------	8,436	24,215	------	2,374,775	13,503	------
1925 ------	8,527	22,537	------	2,575,089	13,804	------
1926 ------	21,167	19,348	------	2,962,698	14,401	------
1927 ------	7,687	27,319	------	5,535,157	14,031	------
1928 ------	6,744	24,921	------	5,901,394	15,489	------
1929 [b] ----	5,966	21,435	------	7,734,945	22,022	------
1930 ------	6,187	31,044	------	9,268,679	16,070	------
1931 ------	6,344	23,029	------	8,385,975	14,437	------

Year	Potter County (bbls.)	Tioga County (bbls.)	Tiona District (bbls.)	Venango County (bbls.)	Warren County (bbls.)	Washington County (bbls.)	Westmoreland County (bbls.)
1886 ---	------	------	------	------	------	3,189,822	------
1887 ---	------	------	------	------	------	2,859,344	------
1888 ---	------	------	------	------	------	2,322,190	------
1889 ---	------	------	------	------	------	3,848,145	------
1890 ---	------	------	667,928†	------	------	3,900,487†	------
1891 ---	------	------	553,730	------	------	2,997,278	------
1892 ---	------	------	475,708	------	------	2,452,388	------
1893 ---	------	------	286,595	------	------	2,077,564	------
1894 ---	------	------	318,611	------	------	1,720,780	------
1895 ---	------	------	325,843	------	------	1,676,676	------
1896 ---	------	------	309,252	------	------	1,975,169	------
1897 ---	------	------	291,585	------	------	2,175,712	------
1898 ---	------	------	251,447	------	------	1,742,677	------
1899 ---	------	------	212,217	------	------	1,460,036	------
1900 ---	------	115,105	256,915	------	------	1,375,341	------
1901 ---	------	37,491	466,909	------	------	1,300,399	------
1902 ---	------	24,881	421,728	------	------	1,396,831	------
1903 ---	------	19,553	578,122	------	------	1,199,838	------
1904 ---	------	15,904	608,165	------	------	1,149,847	------
1905 ---	------	12,674	568,061	------	------	1,149,536	------
1906 ---	------	10,244	515,824	------	------	1,287,714	------
1921 [a] -	13,612	10,095	------	1,454,528	342,640	531,117	150
1922 ---	13,375	8,779	------	1,360,093	516,781	499,893	233
1923 ---	12,135	7,712	------	1,304,206	522,107	474,765	215
1924 ---	10,011	6,836	------	1,236,568	326,852	478,483	257
1925 ---	11,686	5,916	------	1,184,221	294,597	455,554	186
1926 ---	7,395	2,411	------	1,161,924	313,808	449,493	------
1927 ---	6,860	------	------	1,214,568	343,315	455,807	------
1928 ---	8,849	------	------	1,147,047	299,282	500,019	------
1929 [b] -	3,122	------	------	1,291,487	315,322	490,142	------
1930 ---	5,863	------	------	1,132,969	317,025	476,964	------
1931 ---	6,206	------	------	1,083,989	303,078	420,333	[illegible]

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[1] Figures from 1889 to 1906 include the production of the McDonald pool, most of which lies in Washington County.

[2] From 1889 to 1906 includes Beaver and Lawrence counties.

[3] Includes northern and central parts of McKean County, Pennsylvania and extends 6 miles into southeastern Cattaraugus County, New York.

[4] Includes pools in the vicinity of Clarendon and Warren in central Warren County.

[5] Premium lubricating oil from the immediate vicinity of Franklin, Venango County.

[6] Includes western Forest, southwestern Warren, Crawford, Venango, Butler and Armstrong counties.

[7] Includes production from eastern Warren, northeastern Forest, southwestern McKean and Elk counties, with the exception of the Tiona, and Clarendon and Warren districts, for which the production is given separately.

[8] Pools in the vicinity of Tiona in central Warren County.

[9] In 1886 and 1887, the production includes Greene and Washington counties. From 1889 to 1906, the production represents Washington County with the exception of the McDonald pool which is included in Allegheny County.

[a] All county production figures from 1921 on represent crude oil produced within the county limits. Figures from Productive Industries, Pennsylvania. Department of Internal Affairs.

[b] Fayette County produced 1,721 barrels in 1929 and is included in the total for the year.

[c] Bradford District and Allegany County, N. Y. production combined. The Oil City Derrick separation of the two districts is:

	Bradford	Allegany, N. Y.
1888	5,121,025 bbls.	1,177,950 bbls.
1889	6,008,737 "	1,206,613 "

[d] Figures for production of Bradford District from 1868 to 1875 inclusive.

[e] Pumped from gas wells.

* Oil City Derrick's Handbook of Petroleum.

† Pennsylvania Department of Internal Affairs, Petroleum Industry of Pennsylvania.

Production, value and rank of crude oil in Pennsylvania

Year	Production[1] (thousands of bbls.)	Production[2] (thousands of bbls.)	Production[3] (thousands of bbls.)	Total value[4] at well (thousands of dollars)	Price per barrel at well (dollars)	Rank in total U.S. value	Rank in U. S. production
1859			2	40	20.00	1	1
1860			500	4,795	9.59	1	1
1861			2,114	1,036	0.49	1	1
1862			3,057[a]	3,210	1.05	1	1
1863			2,611	8,225	3.15	1	1
1864			2,116	17,055	8.06	1	1
1865			2,498	16,462	6.59	1	1
1866			3,598	13,457	3.74	1	1
1867			3,347	8,066	2.41	1	1
1868			3,646	13,217	3.625	1	1
1869			4,215	23,760	5.637	1	1
1870			5,261	20,307	3.86	1	1
1871			5,205	22,290	4.34	1	1
1872			6,293	22,907	3.64	1	1
1873			9,894	18,106	1.83	1	1
1874			10,927	12,785	1.17	1	1
1875			8,788	11,864	1.35	1	1
1876			8,969	22,979	2.562	1	1
1877			13,135	31,787	2.42	1	1
1878			15,164	18,045	1.19	1	1
1879			19,685	16,909	0.859	1	1
1880		26,043*	26,028[b]	24,596[b]	0.945	1	1
1881		26,638*	27,376[b]	23,516[b]	0.859	1	1
1882			23,368	18,250	0.781	1	1
1883			19,125	20,215	1.057	1	1
1884			20,541	17,152	0.835	1	1
1885			18,118	15,926	0.879	1	1
1886			23,647	16,837	0.712	1	1
1887			20,281	13,527	0.667	1	1
1888		15,321[c]	16,489[b]	14,444[b]	0.876	1	1
1889			19,591	18,435	0.941	1	1
1890		27,239**	28,458[b]	24,673[b]	0.867	1	1
1891			31,424	21,241	0.67	1	1
1892			27,149	15,303	0.556	1	1
1893			19,283	12,564	0.64	1	1
1894			18,078	15,343	0.839	1	1
1895			18,231	24,900	1.366	1	2
1896			19,379	22,982	1.186	1	2
1897			17,983	14,296	0.795	1	2
1898			14,743	13,608	0.923	2	2
1899			13,054	17,053	1.306	3	3
1900			13,258	18,088	1.36	3	3
1901			12,625	15,431	1.22	3	4
1902			12,064	15,266	1.265	3	5
1903			11,355	18,171	1.60	3	5
1904			11,126	18,222	1.64	3	6
1905			10,437	14,653	1.40	3	7
1906			10,257	16,597	1.62	2	5
1907			10,000	17,580	1.76	1	6
1908			9,424	16,881	1.79	5	7
1909			9,299	15,425	1.658	5	7
1910			8,795	11,909	1.354	5	7
1911			8,248	10,894	1.321	5	8
1912			7,838	12,887	1.644	5	8
1913			7,917	19,691	2.487	5	8
1914			8,170	15,574	1.906	5	8
1915			7,839	12,431	1.586	6	7
1916			7,593	19,150	2.522	6	9
1917			7,733	25,154	3.253	7	10
1918			7,408	29,606	3.997	7	9
1919			8,137	33,688	4.13	6	10
1920			7,438	44,464	5.97	8	10
1921	7,251		7,418	24,746	3.33	7	11
1922	7,238		7,425	23,834	3.21	7	10
1923	7,068		7,609	25,320	3.33	8	10
1924	6,495		7,486	27,025	3.61	8	9
1925	6,770		8,097	29,310	3.62	8	8
1926	7,109		8,961	31,930	3.56	8	8
1927	9,639		9,526	29,150	3.06	8	8
1928	9,765		9,956	32,550	3.27	5	8
1929	11,772		11,820	44,800	3.79	5	8
1930	13,006		12,803	33,410	2.61	5	8
1931	11,844		11,892	23,550	1.98	5	9
Totals			853,325	1,399,550			

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[1] Production from Productive Industries by Pennsylvania Department of Internal Affairs.

[2] Production from various sources to separate New York from Pennsylvania production for the years in which the U. S. Geological Survey does not separate the two. These figures include

the production of the entire Bradford District of which it is estimated that 8¼ to 8½ per cent is from Cattaraugus County, N. Y.

[3] Figures of U. S. Geological Survey and Bureau of Mines as given in Mineral Resources of the United States.

[4] Value by U. S. Geological Survey and Bureau of Mines.

[a] In addition it is estimated that for want of a market, 10,000,000 barrels ran to waste in and prior to 1862 from Pennsylvania fields.

[b] Pennsylvania and New York combined.

[c] Pennsylvania production using the Oil City Derrick's Bradford production given in footnote (e) of the preceding table. Mineral Resources figures by the U. S. Geological Survey used for the production of the rest of the State.

* Second Geological Survey of Pennsylvania, Annual Report 1886, Part 2.

** Pennsylvania Department of Internal Affairs, Petroleum Industry of Pennsylvania (1893).

PRODUCTION IN THE BRADFORD DISTRICT

C. R. Fettke, in preparing a detailed report on the Bradford Field for the Pennsylvania Geological Survey, has compiled the following production table for the Bradford District. The figures given include production from the following small pools, Guffey, or Kinzua Creek, Ormsby, and Windfall in Pennsylvania; and the Chipmunk pool in New York. These small pools are immediately adjacent to the Bradford pool and their production is not separable. The bulk of the production listed, however, comes from the Bradford pool proper which lies chiefly in Pennsylvania but extends five to six miles into New York.

Production of petroleum in the Bradford District, 1871-1931

Year	Barrels	Year	Barrels	Year	Barrels
1871	1,000	1892	4,291,061	1913	2,204,000
1872	2,000	1893	3,502,136	1914	2,230,000
1873	2,000	1894	3,359,835	1915	2,256,000
1874	3,000	1895	3,244,808	1916	2,282,000
1875	25,000	1896	3,604,771	1917	2,308,000
1876	382,768	1897	3,904,230	1918	2,334,000
1877	1,468,481	1898	3,444,299	1919	2,360,000
1878	6,208,746	1899	3,206,845	1920	2,386,000
1879	13,914,509	1900	3,022,493	1921	2,415,687
1880	22,212,000	1901	2,757,603	1922	2,577,726
1881	17,959,000	1902	2,506,981	1923	2,602,777
1882	13,294,886	1903	2,326,413	1924	2,480,540
1883	11,883,000	1904	2,187,883	1925	2,747,620
1884	10,564,298	1905	2,115,225	1926	4,725,252
1885	9,752,797	1906	2,022,000	1927	5,793,707
1886	7,580,979	1907	2,048,000	1928	6,361,703
1887	5,306,062	1908	2,074,000	1929	8,137,125
1888	5,765,053	1909	2,100,000	1930	9,334,096
1889	5,608,735	1910	2,128,000	1931	8,811,967
1890	5,452,418	1911	2,152,000		
1891	22,945,069	1912	2,178,000	Total	292,834,584

PRODUCTION CURVES

The curves on the following chart show year by year crude oil production of the world, the United States and of various selected States. In addition, the yearly production of Pennsylvania, the Bradford district, and the McDonald pool are shown on an enlarged scale.

Production figures were obtained from the Mineral Resources volumes and from data collected by the Pennsylvania Geological Survey.

The McDonald pool lies in Washington and Allegheny counties, and the Bradford district lies chiefly in McKean County, Pennsylvania with a small extension into Cattaraugus County, New York. The Bradford production includes small closely associated pools, specifically Kinzua Creek, Ormsby, and Windfall pools in Pennsylvania and the Chipmunk pool in New York.

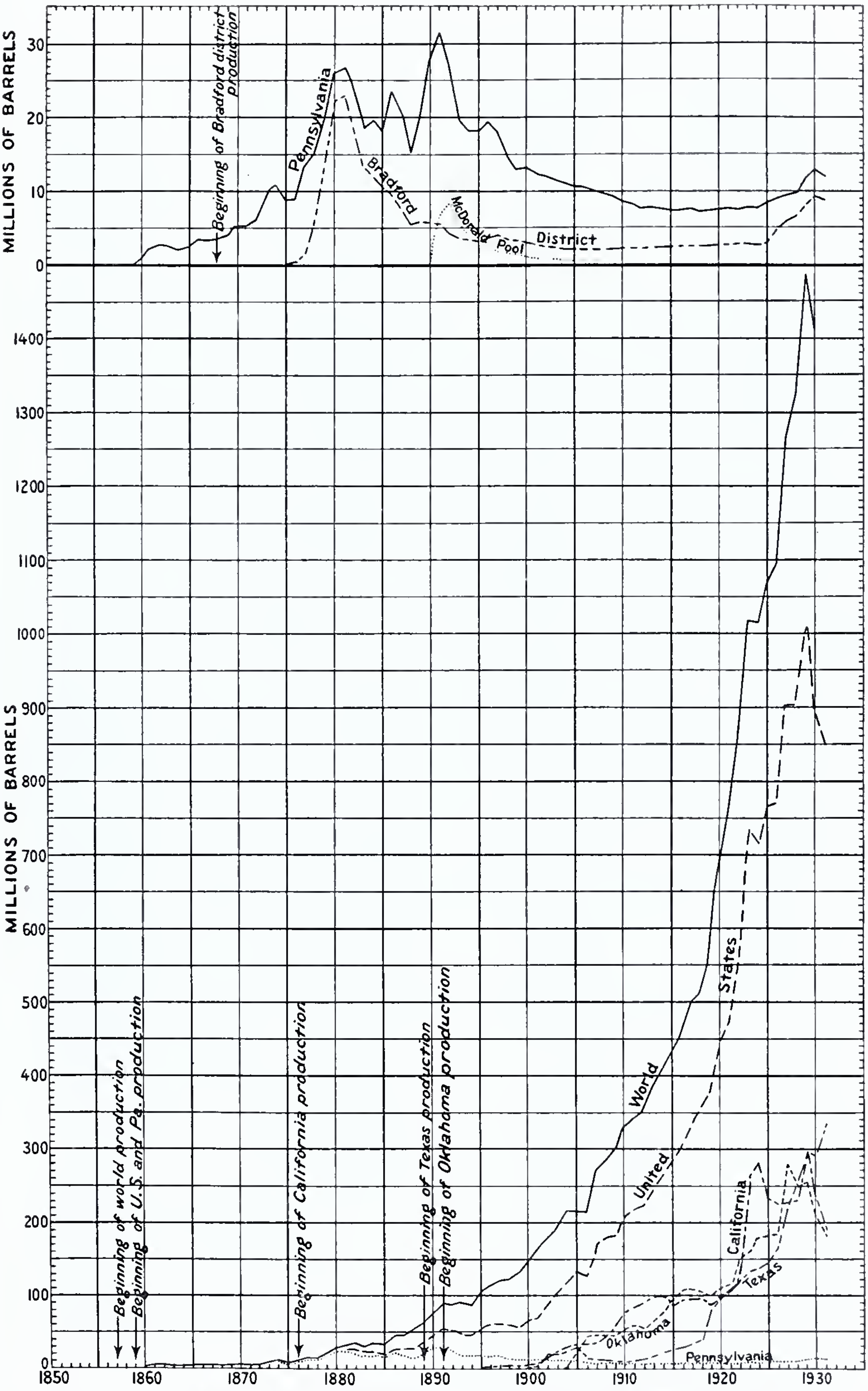

Figure 1. Curves show the yearly production of petroleum in the world, the United States, California, Oklahoma, Texas, Pennsylvania, and, at the top, yearly production of Pennsylvania, Bradford District, and McDonald pool, in barrels of 42 gallons.

Chronological list of oil pools discovered in Pennsylvania

(Pools producing only or principally oil)*

Year	Field	County
1859	Titusville	Crawford
1860	Crooked Run	Butler
1860	Franklin	Venango
1860	Grand Valley	Warren
1860	North Warren	Warren
1860	Oil City	Venango
1860	Smiths Ferry	Beaver
1860	Tidioute	Warren
1861	Bradford	McKean
1864	Botown	Greene
1865	Blackshire or Queensboro	Greene
1865	Northeast	Erie
1865	Pithole	Venango
1865	Enterprise	Warren
1865	Whiteley Creek	Greene
1865	Pleasantville	Venango
1865	Bradys Bend	Armstrong
1867	Dennis Run	Warren
1867	Oleopolis	Venango
1867	Shamburg	Venango
1869	Elk City	Clarion
1869	Petrolia	Butler
1869	Knox	Clarion
1870	Emlenton	Venango
1870	Fagundus	Forest
1870	Fosters	Venango
1870	Raymilton	Venango
1870	Sandy Creek	Venango
1870	West Hickory	Forest
1870	West Liberty	Butler
1871	Sugar Creek	Venango
1872	Cranberry	Venango
1872	Utica	Venango
1873	Concord	Butler
1874	Butler Cross Belt	Butler
1875	Bullion	Venango
1875	Glade Run	Warren
1875	Summit	Butler
1875	Wardwell	Warren
1875	Winfield	Butler
1876	Economy	Beaver
1876	Garrison	Greene
1876	Glade Mills	Butler
1876	Kane	McKean
1876	Kennerdell	Venango
1877	Cookson	Beaver
1877	Lafayette	McKean
1877	Lake Creek	Venango
1877	Tionesta	Forest
1878	Clarendon	Warren
1878	Cornplanter	Warren
1878	Kushequa	McKean
1879	Cherry Grove	Warren
1880	Dewdrop	Warren
1880	Allison Park	Allegheny
1881	Nansen	Elk
1881	Sackett	Elk
1881	Windfall	McKean
1882	Shannopin	Beaver
1883	Balltown	Forest
1884	Homewood & Swissvale	Allegheny
1884	Thorn Creek	Butler
1885	New Galilee	Beaver
1885	Oneida	Butler
1885	Washington–Taylorstown	Washington
1886	Mount Morris	Greene
1886	Pleasant Unity	Westmoreland
1886	Saxonburg	Butler
1887	Brush Creek	Allegheny
1888	Canonsburg	Washington
1888	Clarion	Clarion
1888	Nineveh	Greene
1888	Shamburg	Clarion
1889	Hookstown	Beaver
1889	Wildwood	Allegheny
1890	Burgettstown	Washington
1890	Chartiers	Allegheny
1890	Coraopolis	Allegheny
1890	Florence	Washington
1890	Glade	Butler
1890	Mars	Butler
1890	McCurdy	Allegheny
1890	McDonald	Washington
1890	Richhill	Greene
1890	Slippery Rock	Lawrence
1891	Clintonville	Butler
1891	Moon	Allegheny
1891	Muddy Creek	Butler
1892	Evans City	Butler
1893	Garvin	Butler
1893	Keown	Allegheny
1894	Glenhazel	Elk
1894	North Washington	Butler
1894	Ormsby	McKean
1894	Venice	Washington
1895	Glenfield	Allegheny
1895	Lickskillet	Allegheny
1896	Bristoria	Greene
1896	Criders	Butler
1896	New Freeport	Greene
1896	Rosenburg	Butler
1897	Crows Run	Beaver
1897	Fonner	Greene
1897	Grays Fork	Greene
1897	Gaines	Tioga
1898	Bellevue	Allegheny
1898	Board Tree	Greene
1898	Imperial	Allegheny
1899	Ingomar	Allegheny
1899	Lagonda	Washington
1899	Moon Run	Allegheny
1900	Aleppo	Greene
1900	Aten	Allegheny
1900	Carnegie	Allegheny
1900	Deer Creek	Allegheny
1900	Hammersley Fork	Clinton
1900	Linden	Washington
1900	Plum Township	Allegheny
1900	Ross	Washington
1900	Sharon	Mercer
1900	St. Marys	Elk
1900	Zelienople	Butler
1902	Unionville	Butler
1905	Volant	Mercer
1906	Dague	Washington
1906	Miola	Clarion
1910	Bessemer	Lawrence
1910	Callery	Butler
1910	White Ash	Allegheny
1915	Sugar Run	McKean
1917	Hookstown	Beaver
1917	Monaca	Beaver
1917	New Bethlehem	Clarion
1920	Kendall	Beaver
1921	Stoneboro	Mercer
1921	Sparta	Crawford
1921	Spring Creek	Warren
1922	Meadville	Crawford
1924	Campbell Farm	Allegheny
1924	Perry Township	Greene
1925	Morris Township	Greene
1925	Rutan	Greene
1928	Atlantic	Crawford

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*Second Geological Survey of Pennsylvania.
Oil City Derrick.
Petroleum in United States by Arnold and Kemnitzer.

CHRONOLOGICAL LIST OF OIL POOL DISCOVERIES

The list of oil pools in the order of discovery is not complete as exact dates of some pools could not be ascertained. Pools for which no definite time of discovery could be found in the old records, are omitted from the table.

NATURAL GAS PRODUCTION

It is definitely known that natural gas was used commercially in 1872 when gas was piped to Titusville to supply 250 customers. This gas was piped from a well 5½ miles distant. Very probably natural gas was produced and sold in Pennsylvania previous to 1872. However, no statistics were kept on the quantity and value of natural gas produced and consumed until 1882.

The Mineral Resources publications kept only the value of gas produced in Pennsylvania from 1882 to 1906. In the latter years quantities as well as value of natural gas produced were compiled.

Since 1921, statistics on the interstate transportation of natural gas have been gathered and published in Mineral Resources of the United States. Pennsylvania, since 1921, has consumed more gas than it produces. Most of this additional gas is brought from West Virginia which transported 34,549,000 M. cubic feet into Pennsylvania in 1929. New York in the same year transported 103,000 M. cubic feet into Pennsylvania. Of the gas produced in Pennsylvania and transported to other states, the division during the same year is: to New York 10,011,000 M. cubic feet; to West Virginia 2,645,000 M. cubic feet; and to Ohio 1,071,000 M. cubic feet.

Preliminary figures for natural gas production in Pennsylvania during 1932 were 63,286,242 M. cu. ft. (Pennsylvania Department of Internal Affairs).

Quantity and value of natural gas produced in Pennsylvania; also, interstate transportation and rank of Pennsylvania in natural gas production and consumption

Year	Quantity and value produced, including deliveries to other States						Quantity and value consumed, including receipts from other States				Interstate transportation		Estimated mileage of natural gas lines in Pennsylvania	Rank in U. S. production	Rank in U. S. consumption
			Estimated value at well		Value at point of consumption				Value at point of consumption						
	Quantity (Thousands of M. cu. ft.)	Per cent of U. S. production	Total value (Thousands of dollars)	Ave. per M. cu. ft. (cents)	Total value (Thousands of dollars)	Ave. per M. cu. ft. (cents)	Quantity consumed (Thousands of M. cu. ft.)	Per cent of U. S. consumption	Total value (Thousands of dollars)	Ave. per M. cu. ft. (cents)	Quantity transported into Pa. (Thousands of M. cu. ft.)	Quantity transported out of Pa. (Thousands of M. cu. ft.)			
1882	1,611,066*	------	------	------	$ 75	8.0*	------	------	------	------	------	------	------	1	1
1883		------	------	------	200		------	------	------	------	------	------	------	1	1
1884		------	------	------	1,100		------	------	------	------	------	------	------	1	1
1885		------	------	------	4,500		------	------	------	------	------	------	------	1	1
1886		------	------	------	9,000		------	------	------	------	------	------	------	1	1
1887		------	------	------	13,749		------	------	------	------	------	------	------	1	1
1888		------	------	------	19,282		------	------	------	------	------	------	------	1	1
1889		------	------	------	11,594		------	------	------	------	------	------	1,261	1	1
1890		------	------	------	9,551		------	------	------	------	------	------	1,462	1	1
1891		------	------	------	7,834		------	------	------	------	------	------	1,525	1	1
1892		------	------	------	7,376		------	------	------	------	------	------	2,246	1	1
1893		------	------	------	6,488		------	------	------	------	------	------	2,313	1	1
1894		------	------	------	6,279		------	------	------	------	------	------	2,981	1	1
1895		------	------	------	5,852		------	------	------	------	------	------	4,239	1	1
1896		------	------	------	5,529		------	------	------	------	------	------	5,078	1	1
1897		------	------	------	6,243		------	------	$ 5,393	------	------	------	5,354	1	1
1898		------	------	------	6,807		------	------	6,064	------	------	------	6,525	1	1
1899		------	------	------	8,337		------	------	7,927	------	------	------	6,966	1	1
1900		------	------	------	10,215		------	------	9,813	------	------	------	8,308	1	1
1901	------	------	------	------	12,688	------	------	------	11,786	------	------	------	9,074	1	1
1902	------	------	------	------	14,352	------	------	------	13,943	------	------	------	9,254	1	1
1903	------	------	------	------	16,183	------	------	------	16,060	------	------	------	10,206	1	1
1904	------	------	------	------	18,140	------	------	------	17,206	------	------	------	11,446	1	1
1905	------	------	------	------	19,197	------	------	------	19,237	------	------	------	12,069[b]	1	1

1906	138,161				18,558	13.4	162,095		21,085	13.0				1	1
1907	135,516				18,844	13.9	164,541		22,918	13.9				1	1
1908	130,476				19,105	14.6	147,790		20,678	14.0				1	1
1909	127,697				20,475	16.0	163,656		21,639	13.2				2	1
1910	126,867				21,057	16.6	168,876		23,935	14.2				2	1
1911	108,869				18,521	17.3	159,104		23,940	15.1				2	1
1912	112,150				18,540	16.5	173,656		26,486	15.3				2	1
1913	118,860				21,696	18.3	177,463		28,710	16.2				2	1
1914	110,745				20,840	18.8	164,835		28,439	17.3				2	1
1915	113,692				21,140	18.6	176,367		30,087	17.1				2	1
1916	130,484				24,513	18.78	201,461		35,016	17.4				2	1
1917	133,397				28,716	21.53	202,259		40,774	20.2				3	1
1918	123,813	17.2			38,609	31.18	177,140		44,777	25.3				3	1
1919	113,489				32,520	28.7	146,553		41,269	28.2				3	1
1920	125,787				40,726	32.4	161,397		51,863	32.1				3	1
1921	86,144	13.0	[a]		32,815	38.1	100,615	15.2	38,246	38.0	25,205	10,734		3	3
1922	101,276	13.3	$20,255	20.0	39,835	39.3	130,733	17.2	50,657	38.7	40,287	10,830		3	1
1923	112,562	11.2	25,887	23.0	45,873	40.8	138,478	13.7	54,742	39.5	38,396	12,480		4	2
1924	105,863	9.3	25,037	23.7	45,546	43.0	123,932	10.9	52,005	42.0	31,789	13,720		6	4
1925	101,632	8.6	24,392	24.0	47,098	46.3	119,475	10.0	53,946	45.2	30,520	12,677		6	5
1926	107,089	8.2	25,112	23.4	50,040	46.7	125,836	9.6	56,724	45.1	33,528	14,781		6	5
1927	105,709	7.3	26,502	25.1	49,135	46.5	121,982	8.4	54,473	44.7	30,360	14,088		6	5
1928	99,466	6.3	29,114	29.3	48,432	48.7	116,150	7.4	54,388	46.8	31,833	15,149		6	6
1929	101,951	5.3	28,189	27.6	48,821	47.9	122,876	6.4	56,900	46.3	34,652	13,727	5,200[c]	6	6
1930	88,706		25,725	29.0	44,530	50.2	108,218		51,783	47.8	25,693†	11,756†		6	
1931†	74,084						96,746[d]		46,491	48.1	9,091	387			
Totals	4,545,551		230,213		1,036,556		3,852,234		$1,139,400		331,344	130,329			

* Arnold and Kemnitzer—Petroleum in United States and its Possessions.
† Productive Industries, Pennsylvania Department of Internal Affairs.
[a] Figures not available for value at well prior to 1922.
[b] Total miles of pipe laid up to December 31, 1905.
[c] Miles of natural gas trunk lines.
[d] Includes 3,571 M. cu. ft. by-product coke oven gas.

DOMESTIC AND INDUSTRIAL CONSUMPTION OF NATURAL GAS

Not until 1906 was the consumption of natural gas subdivided into domestic and industrial consumption. In 1909 the total industrial consumption was further subdivided into various branches of industry. The following table shows the various subdivisions.

Industrial and domestic uses, consumption, value and number of consumers of natural gas in Pennsylvania

Year	Industrial Subdivisions							
	Field operations (drilling, pumping and operating gasoline recovery plants)		Natural gas-gasoline plants[1]			Manufacturing plants[2]		
				Value at points of consumption			Value at points of consumption	
	Estimated consumption (thousands of M. cu. ft.)	Estimated value at points of consumption (thousands of dollars)	Quantity consumed (thousands of M.cu.ft.)	Total (thousands of dollars)	Aver. per M. cu. ft. (cents)	Quantity consumed (thousands of M.cu.ft.)	Total (thousands of dollars)	Aver. per M. cu. ft. (cents)
1909	--------	--------	--------	--------	--------	113,903	$10,904	9.5
1910	--------	--------	--------	--------	--------	115,465	11,690	10.1
1911	--------	--------	--------	--------	--------	103,228	11,385	11.0
1912	--------	--------	--------	--------	--------	114,618	13,127	11.5
1913	--------	--------	--------	--------	--------	117,074	14,338	12.3
1914	--------	--------	--------	--------	--------	104,073	13,328	12.9
1915	--------	--------	--------	--------	--------	113,958	14,619	12.8
1916	--------	--------	--------	--------	--------	131,572	18,035	13.7
1917	--------	--------	--------	--------	--------	123,851	20,477	16.5
1918	--------	--------	--------	--------	--------	104,304	23,775	22.8
1919	8,232	$1,285	776	$114	14.7	77,227	18,591	25.7
1920	11,778	3,116	541	87	16.1	76,242	22,073	29.0
1921	7,041	1,623	704	110	15.6	34,466	11,491	33.3
1922	4,900	1,182	--------	--------	--------	a	a	a
1923	10,027	2,304	--------	--------	--------	a	a	a
1924	9,494	2,245	--------	--------	--------	a	a	a
1925	7,845	1,883	--------	--------	--------	a	a	a
1926	7,988	1,873	--------	--------	--------	a	a	a
1927	7,990	2,003	--------	--------	--------	a	a	a
1928	6,606	2,229	--------	--------	--------	a	a	a
1929	6,929	2,118	--------	--------	--------	a	a	a
1930	6,290	2,091	--------	--------	--------	a	a	a
1931*	--------	--------	--------	--------	--------	--------	--------	--------
Total	95,120	$23,952	2,021	$311	--------	1,329.981	203,833	--------

Industrial and domestic uses, consumption, value and number of consumers of natural gas in Pennsylvania

Year	Industrial Subdivisions						
	Fuel at petroleum refineries, electric power plants and other industrial plants					Number of industrial consumers	
	Quantity consumed (Thousands of M. cu. ft.)			Value at points of consumption			
	Petroleum refineries	Electric power plants	Other industrial plants[3]	Total (thousands of dollars)	Ave. per M. cu. ft. (cents)	Gasoline and other manufacturing	Other Industrial plants[4]
1893	-----	-----	-----	-----	-----	-----	274
1894	-----	-----	-----	-----	-----	-----	380
1895	-----	-----	-----	-----	-----	-----	656
1896	-----	-----	-----	-----	-----	-----	858
1897	-----	-----	-----	-----	-----	-----	1,124
1898	-----	-----	-----	-----	-----	-----	1,021
1899	-----	-----	-----	-----	-----	-----	1,236
1900	-----	-----	-----	-----	-----	-----	1,296
1901	-----	-----	-----	-----	-----	-----	1,743
1902	-----	-----	-----	-----	-----	-----	2,448
1903	-----	-----	-----	-----	-----	-----	2,834
1904	-----	-----	-----	-----	-----	-----	2,929
1905	-----	-----	-----	-----	-----	-----	2,845
1906	-----	-----	-----	-----	-----	-----	3,307
1907	-----	-----	-----	-----	-----	-----	3,812
1908	-----	-----	-----	-----	-----	-----	4,577
1909	-----	-----	10,024	$1,044	10.4	-----	5,377
1910	-----	-----	10,006	1,272	12.7	-----	4,102
1911	-----	-----	10,371	1,391	13.4	-----	4,597[b]
1912	-----	-----	9,707	1,206	12.4	1,987	1,455
1913	-----	-----	13,690	1,847	13.5	2,134	2,239
1914	-----	-----	10,568	1,409	13.3	1,934	2,373
1915	-----	-----	11,059	1,459	13.2	2,032	2,664
1916	-----	-----	14,283	1,820	12.8	1,801	2,875
1917	-----	-----	15,272	2,186	14.3	1,433	2,984
1918	-----	-----	12,996	2,229	17.15	1,718	2,768
1919	a	a	6,665	1,527	22.9	1,909	3,597
1920	a	566	6,675	1,928	28.9	1,660	3,258
1921	a	493	4,454	1,504	33.8	5,418	2,446
1922	a	a	70,849	22,409	31.6	2,411[x]	2,938[x c]
1923	a	a	69,483	22,824	32.8	2,282[x]	2,885[x]
1924	a	a	55,542	18,028	32.5	2,266[x]	2,951[x]
1925	a	a	55,833	18,563	33.2	2,164[x]	3,023[x]
1926	a	a	61,700	20,939	33.9	2,045[x]	2,432[x]
1927	1,727	106	60,365	21,081	33.9	2,174[x]	1,818[x]
1928	1,173	73	55,327	19,750	34.9	2,203[x]	2,089[x]
1929	939	69	61,716	22,075	35.2	2,259[x]	2,495[x]
1930	1,121	62	48,771	17,780	35.6	2,971[x]	2,516[x]
1931*	-----	-----	-----	-----	-----	2,040	2,724
Total	4,960	1,369	675,356	204,271	-----	-----	-----

Industrial and domestic uses, consumption, value and number of consumers of natural gas in Pennsylvania

Year	Total industrial consumption and value				Domestic consumption and value		
		Value at points of consumption				Value at points of consumption	
	Quantity consumed (thousands of M.cu.ft.)	Total (thousands of dollars)	Ave. per M. cu. ft. (cents)	Number[d] of domestic consumers	Quantity consumed (thousands of M.cu.ft.)	Total (thousands of dollars)	Ave. per M. cu. ft. (cents)
1889	----------	----------	----------	150,000	----------	----------	----------
1890	----------	----------	----------	----------	----------	----------	----------
1891	----------	----------	----------	----------	----------	----------	----------
1892	----------	----------	----------	153,058	----------	----------	----------
1893	----------	----------	----------	119,524	----------	----------	----------
1894	----------	----------	----------	120,571	----------	----------	----------
1895	----------	----------	----------	212,834	----------	----------	----------
1896	----------	----------	----------	204,447	----------	----------	----------
1897	----------	----------	----------	201,059	----------	----------	----------
1898	----------	----------	----------	213,410	----------	----------	----------
1899	----------	----------	----------	232,060	----------	----------	----------
1900	----------	----------	----------	229,730	----------	----------	----------
1901	----------	----------	----------	326,912[d]	----------	----------	----------
1902	----------	----------	----------	185,678	----------	----------	----------
1903	----------	----------	----------	214,432	----------	----------	----------
1904	----------	----------	----------	238,481	----------	----------	----------
1905	----------	----------	----------	257,416	----------	----------	----------
1906	120,959	$11,956	9.9	273,184	41,136	$9,129	22.2
1907	119,700	12,071	10.1	295,115	44,841	10,847	24.2
1908	105,587	10,537	10.0	307,585	42,203	10,142	24.0
1909	123,927	11,947	9.6	294,781	39,729	9,692	24.4
1910	125,471	12,962	10.3	321,430	43,405	10,972	25.3
1911	113,599	12,776	11.3	330,537	45,506	11,164	24.5
1912	124,325	14,333	11.5	345,765	49,331	12,153	24.6
1913	130,764	16,185	12.4	400,823	46,699	12,524	26.8
1914	114,642	14,737	12.9	415,644	50,193	13,702	27.3
1915	125,019	16,078	12.9	440,673	51,348	14,009	27.3
1916	145,854	19,856	13.6	463,264	55,605	15,159	27.3
1917	139,124	22,663	16.3	480,500	63,136	18,111	28.7
1918	117,300	26,004	22.2	481,275	59,840	18,773	31.4
1919	87,900	21,517	24.5	498,816	58,653	19,752	33.7
1920	95,236	27,204	28.6	510,178	66,161	24,659	37.3
1921	46,665	14,728	31.6	468,615	53,950	23,518	43.6
1922	75,749	23,591	31.1	534,100	54,984	27,066	49.2
1923	79,510	25,128	31.6	548,440	58,968	29,614	50.2
1924	65,036	20,273	31.2	568,200	58,896	31,732	53.9
1925	63,678	20,446	32.1	582,520	55,797	35,500	60.0
1926	69,688	22,812	32.7	599,900	56,148	33,912	60.4
1927	70,188	23,084	32.9	610,720	51,794	31,389	69.6
1928	63,179	21,979	34.8	615,360	52,971	32,409	61.2
1929	69,653	24,193	34.7	634,180	53,223	32,707	61.5
1930	56,244	19,871	35.3	637,000	51,974	31,912	61.4
1931[x]	46,339	15,734	34.0	625,740	50,407	30,757	61.0
Total	2,495,336	482,665	----------	----------	1,356,898	549,304	----------

[1] Figures represent only the actual decrease in volume of gas treated for gasoline. Figures are separated from field operations column.

[2] Includes steel works, ceramic plants, glass works, cement plants, chemical works, salt works, bakeries, etc.

[3] Includes miscellaneous industrial plants up to 1922 when manufacturing plants are included in the group.

[4] Includes public utility plants, petroleum refineries, etc.

[x] Figures from Productive Industries, Pennsylvania Department of Internal Affairs.

[a] Included in other industrial column.

[b] Industrial consumers not subdivided prior to 1912.

[c] From 1922 on; other consumers include municipalities using gas, etc.

[d] Prior to 1902, the figures represent the number of fires supplied and not the number of domestic consumers.

PRODUCTION OF NATURAL GAS BY COUNTIES

The statistics, showing the production of natural gas by counties, were compiled by the Pennsylvania Department of Internal Affairs. The figures were discontinued from 1927 to 1931 because of the inaccuracies in the producers reports. It is very difficult to arrange county production statistics of such a mobile material as gas. However, the figures given in the table will help formulate a comparison of the production of the various counties.

Natural gas produced in Pennsylvania by counties
*(Thousands of M. cu. ft.)**

County	1920	1921	1922	1923	1924	1925	1926	1927	1931	1932
Allegheny	27,618	6,479	8,357	8,241	7,223	7,783	6,581	6,450	3,277	2,824
Armstrong	2,303	9,862	13,341	15,259	14,926	12,715	14,267	16,726	9,741	7,554
Beaver	16	308	291	430	361	339	303	277	244	190
Butler	6,108	2,091	2,051	2,265	2,297	2,723	4,412	4,688	2,369	1,372
Cambria	14	924	8	3	5	4	2	-------	786	-------
Centre	2	-------	-------	-------	-------	-------	-------	-------	-------	-------
Clarion	624	10,400	8,507	10,539	10,421	12,354	13,634	15,063	10,212	8,308
Clearfield	1	-------	-------	-------	-------	-------	-------	-------	5	436
Elk	2,361	7,323	6,718	6,740	5,579	6,545	5,977	4,953	3,758	2,949
Erie	6	407	10	10	13	10	9	8	6	7
Fayette	1,721	1,735	2,596	3,022	2,267	2,812	2,320	2,201	2,010	1,421
Forest	70	452	227	996	369	484	642	493	2,935	483
Greene	2,866	9,288	16,677	19,542	17,825	17,627	18,205	17,628	10,411	8,977
Indiana	1,619	459	754	1,029	1,904	1,712	2,427	2,803	1,593	1,168
Jefferson	1,833	8,246	9,083	8,494	10,714	9,394	10,499	10,567	8,127	6,649
Lawrence	1,171	12	26	33	71	70	30	48	11	14
McKean	2,990	4,744	5,253	4,960	3,547	4,493	3,703	3,992	2,109	2,255
Mercer	1,324	439	474	389	373	157	165	42	130	114
Potter	1,655	1,763	2,331	1,898	1,280	1,746	1,759	1,782	841	2,075
Somerset	1	-------	-------	-------	-------	-------	-------	-------	-------	-------
Tioga	736	-------	-------	-------	-------	-------	-------	-------	1,510	4,372
Venango	20,820	4,503	3,446	3,668	3,828	2,153	2,386	2,072	2,731	2,044
Warren	3,434	635	898	891	570	559	621	528	629	475
Washington	6,766	5,484	10,454	11,758	12,736	11,832	14,710	16,051	7,503	7,058
Westmoreland	7,885	7,391	8,210	8,211	6,662	6,556	6,208	6,145	3,146	2,541
Total	93,944	82,945	99,712	108,378	102,971	102,068	108,860	112,517	74,084	63,286

* Report on Productive Industries—Pennsylvania Department of Internal Affairs.

CHRONOLOGICAL LIST OF GAS POOL DISCOVERIES

The list of gas pools in the order of their discovery is not complete, as exact dates of discovery of some of the pools could not be ascertained. Whenever no definite date could be set, the pool was not included in the list given below.

Chronological list of gas pools discovered in Pennsylvania
(Pools producing only or principally gas)*

Year	Field	County
1860	Erie	Erie
1861	Bradys Run	Beaver
1861	Betula	McKean
1861	Colegrove	McKean
1861	Dunkard Creek	Greene
1865	Buttenbender	Clarion
1865	Blair	Clarion
1865	Carrolltown	Cambria
1865	Catfish Run	Clarion
1865	Cherry Run	Clarion
1865	Enterprise	Warren
1865	Mill Creek	Clarion
1869	Butler	Butler
1870	Fryburg	Clarion
1870	Leeper	Clarion
1870	Lucinda	Clarion
1870	Pine Grove	Clarion
1871	Johnetta	Armstrong
1873	McCrea Furnace	Armstrong
1874	Goheenville	Armstrong

Chronological list of gas pools discovered in Pennsylvania—(Cont'd.)

Year	Field	County
1875	Cowanshannock	Armstrong
1875	French Corner	Armstrong
1875	Limestone Run	Armstrong
1875	Madison	Armstrong
1875	Mahoning Furnace	Armstrong
1875	Shannondale	Clarion
1875	Sheffield	Warren
1875	Sherrett	Armstrong
1875	Smethport	McKean
1877	Ridgway	Elk
1878	Fairview or Girard	Erie
1878	Hazelhurst	McKean
1878	Marvindale	McKean
1878	Murrysville	Westmoreland
1878	Tarentum	Allegheny
1879	Wetmore	McKean
1880±	Freeport	Armstrong
1881	Marienville	Forest
1881	New Sheffield	Beaver
1882	Hickory	Washington
1883	Juneau	Indiana
1883	Mill Creek	El
1884	Brookville	Jefferson
1884	Clinton	Butler
1885	Beaver	Crawford
1885±	Millstone	Jefferson
1886	Bear Creek	Elk
1886	Braeburn	Westmoreland
1886	Coudersport or Roulette	Potter
1887	Bakerstown	Allegheny
1887	Belle Vernon	Washington
1887	Buffalo	Washington
1887	Webster	Westmoreland
1887	Clifton	Allegheny
1887	Fayette	Fayette
1888	Hallton	Elk
1888	Masontown	Fayette
1889	Cherrytree	Cambria
1889	Waynesburg	Greene
1890	Eldersville	Washington
1890	Elizabeth	Allegheny
1890	Willett	Indiana
1890	Atwood	Armstrong
1891	Rodfield	Allegheny
1891	Marion Center	Indiana
1893	Rockville	Armstrong
1893	Big Meadows	Lawrence
1894	Finleyville	Washington
1894	Girty	Armstrong
1894	New Salem	Armstrong
1894	Roaring Run	Armstrong
1894	Nine Mile Run	Allegheny
1894	Homestead	Allegheny
1894	Little Mud Lick Creek	Armstrong
1896	Peters	Butler
1897	Say	Armstrong
1898	Plum Creek	Armstrong
1898	West Newton	Westmoreland
1899	Lantz	Greene
1899	Shellhammer	Armstrong
1900	Apollo	Armstrong
1900	Bridgeville	Allegheny
1900	Creekside	Indiana
1900	Forward	Allegheny
1900	Geneva	Crawford
1900	Haddonville	Fayette
1900	Rattlesnake Pool	Elk
1900	Saltsburg	Westmoreland
1900	Grapeville-Arona	Westmoreland
1900	Leechburg	Armstrong
1900	Moravia	Lawrence
1901	Delmont	Westmoreland
1902	Ford City	Armstrong
1902	Zollarsville	Washington
1902	McNees	Armstrong
1902	Whitesburg	Armstrong
1904	Mount Jackson	Lawrence
1905	North Buffalo	Armstrong
1905	Woodruff	Greene
1906	Mehaffey	Washington
1907	Latrobe	Westmoreland
1908	Pine Run	Westmoreland
1909	Siegel	Jefferson
1910	Sutersville	Westmoreland
1911	Vandergrift	Armstrong
1912	Sligo	Clarion
1915	Mifflin	Allegheny
1915	Warsaw	Jefferson
1917	Gaines	Tioga
1917	Clugston	Allegheny
1917	Knoxville	Tioga
1919	Lincoln	Allegheny
1919	Wolf Creek	Mercer
1919	Bellsano	Cambria
1919	McKeesport	Allegheny
1920	McCance	Westmoreland
1920	Broken Straw	Warren
1920	Harrisville	Butler
1920	Slate Lick	Armstrong
1920	Walkchalk	Armstrong
1920	Sandy Lake	Mercer
1920	McCandless	Butler
1920	Seaton Creek	Butler
1920	Oliveburg	Jefferson
1921	Columbus	Warren
1921	Perryopolis	Fayette
1921	Connellsville	Fayette
1921	High House	Fayette
1921	Concord	Erie
1924	North Point	Jefferson
1925	Horton	Elk
1927	Truittsburg	Clarion
1928	Buffalo Township	Butler
1929	Driftwood Branch	Cameron
1929	Highland	Clarion
1930	New Alexandria	Westmoreland
1930	Tioga or Farmington Township	Tioga
1931	Potter County or Hebron Centre	Potter

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*Data from Second Geological Survey of Pennsylvania, Oil City Derrick, Petroleum in the United States by Arnold and Kemnitzer.

CARBON BLACK

The production of carbon black is dependent upon the quantity of cheap gas available. As there is a great demand for natural gas in Pennsylvania for domestic and industrial uses, the price of the gas is high. This condition forced the abandonment of the carbon black industry in Pennsylvania in 1926.

Statistics on carbon black were first compiled in 1919 when two plants were in operation in Pennsylvania. One of the plants was abandoned in 1920, the other located in McKean County, operated until some time in 1926 when it was abandoned. Production statistics on carbon black in Pennsylvania are combined with other States during the years 1921 to 1926 and are not separable.

*Carbon black produced from natural gas in Pennsylvania**

Year	Number plants	Carbon black produced: Quantity (pounds)	Value (dollars)	Ave. price per pounds (cents)	Ave. yield per M. cu. ft. (pounds)	Gas used: Quantity (M. cu. ft.)	Per cent of United States production
1919	2	315,500	$48,114	15.3	1.4	227,700	----------------
1920	2	246,612	28,424	11.5	1.2	197,290	1.0—

NATURAL GAS-GASOLINE

Experiments near Titusville and Tidioute on the extraction of gasoline from natural gas were performed as far back as 1903. The infant industry remained in the experimental stage until 1909 when it was placed on a commercial basis. Previous to 1916, the greater proportion of the gasoline was recovered by the compression and vacuum pump method from the "wet" gas obtained from oil wells.

The absorption process was developed through research work done in Pittsburgh during 1912 and 1913. This process made it commercially possible to extract gasoline from "dry" gas that contained too little gasoline to warrant treatment by the compression method.

It has been demonstrated by experiments that the extraction of the gasoline from gas does not reduce appreciably the value of the gas for heat, power and light. The removal of the gasoline can be regarded as beneficial, in that the water in this gas is removed at the same time. Also the removal of the gasoline prevents the disintegration by the gasoline of the rubber gaskets in the pipe lines.

Synonyms for natural gas-gasoline are casing-head or raw, or unblended gasoline.

Statistics on natural gas-gasoline were first compiled in 1911 and are collected in the following table. A method of transportation, not mentioned in the table, is the turning of the casing-head gasoline into crude oil pipe lines. The Mineral Resources publications mention only two years in which this practice was followed in Pennsylvania. During 1923, 251,611 gallons, and in 1929, 2,000 gallons of raw gasoline produced in Pennsylvania were turned into crude oil pipe lines.

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*Data from Mineral Resources of United States, by U. S. Geological Survey.

Natural gas-gasoline tables for Pennsylvania showing production, value, amount of natural gas treated, yield, types of plants, rank and percentage of U. S. production

Year	Quantity produced (thousands of gallons)	Value at plant		Estimated quantity of natural gas treated for gasoline			
		Total (thousands of dollars)	Ave. per gallon (cents)	Quantity (thousands of M. cu. ft.)	Average yield per M. cu. ft. (gallons)		
					Compression	Absorption	Average
1911	1,467	110	7.5	526	----------	----------	2.80
1912	2,041	217	10.6	723	----------	----------	2.80
1913	3,680	405	11.0	1,372	----------	----------	2.68
1914	4,612	359	7.8	1,560	----------	----------	2.89
1915	5,899	570	9.66	1,838	----------	----------	2.73
1916	9,715	1,726	17.8	38,491	2.50	0.08	0.25
1917	13,826	2,778	20.0	49,487	2.52	0.105	0.28
1918	15,775	3,249	20.6	56,982	2.33	0.12	0.28
1919	20,284	4,407	21.7	56,281	2.37	0.17	0.36
1920	21,151	4,382	20.7	60,952	2.04	0.18	0.35
1921	19,856	3,354	16.9	46,336	2.28	0.20	0.43
1922	18,518	3,145	17.0	51,329	----------	----------	0.36
1923	19,132	2,560	13.4	55,238	----------	----------	0.3
1924	19,254	2,266	11.8	63,104	----------	----------	0.3
1925	18,850	2,185	11.6	59,686	----------	----------	0.3
1926	20,343	2,454	12.1	63,819	----------	----------	0.3
1927	16,744	1,648	9.8	47,424	----------	----------	0.4
1928	16,571	1,570	9.5	49,542	----------	----------	0.3
1929	18,411	1,676	9.1	50,789	----------	----------	0.36
1930	15,900	1,133	----------	----------	----------	----------	----------
Total	282,029	40,194	----------	755,479	----------	----------	----------

Year	Ratio (percentage) of natural gas treated for gasoline		Number of gasoline recovery plants			
	To quantity of gas produced	To quantity of gas consumed	Compression	Absorption[1] and combination	Charcoal	Total
1911	----------	----------	----------	----------	----------	50
1912	----------	----------	----------	----------	----------	83
1913	----------	----------	----------	----------	----------	113
1914	----------	----------	----------	----------	----------	119
1915	----------	----------	----------	----------	----------	139
1916	----------	----------	185	10	----------	195
1917	----------	----------	234	17	----------	251
1918	----------	----------	259	23	----------	282
1919	----------	----------	314	29	----------	343
1920	----------	----------	279	27	----------	306
1921	----------	----------	235	29	----------	264
1922	----------	----------	168	27	----------	195
1923	49	40	168	27	3	196
1924	60	51	164	23	4	191
1925	59	50	143	20	4	167
1926	60	51	111	26	4	141
1927	45	39	119	24	4	147
1928	50	43	106	23	2	131
1929	50	41	110	24	2	136
1930	----------	----------	----------	----------	----------	----------
Total	----------	----------	----------	----------	----------	----------

Natural gas-gasoline tables for Pennsylvania showing production, value, amount of natural gas treated, yield, types of plants, rank and percentage of U. S. production

Year	Quantity produced by processes (thousands of gallons)				Stock at plants on December 31 (thousands of gallons)		Range of gravity of gasoline produced (°Baume)	U. S. production	
	Compression	Absorption and combination[1]	Charcoal	Drip	Unblended	Blended		Per cent	Rank
1911							75–100	20	3
1912							58–105	17	2
1913							58–110	15	3
1914							70– 98	11	4
1915	[a]	[a]					66–100	9	4
1916	6,722	2,993					64– 98	9	4
1917	9,001	4,815					66–100	5.6	4
1918	9,159	6,616					55– 95	5.6	4
1919	11,684	8,600					60– 98	5.8	4
1920	10,981	10,170					70– 96	5	5
1921	11,559	8,298[b]					60– 98	4.4	5
1922	9,116	9,345		57				3.7	7
1923	7,943	10,404	712	73				2.3	7
1924	7,315	10,716	1,076	147				2.1	8
1925	7,706	9,066	2,078		1,348	301		1.7	9
1926	6,718	11,059	2,566		1,082	171		1.5	9
1927	6,061	9,073	1,610		1,100	139		1.0	9
1928	5,026	10,752	793		802	143		0.9	9
1929	5,145	12,652	614		773	103		0.8	9
1930								0.7	9
Total									

[1] Combination process combines the absorption with the compression or charcoal processes.
[a] Prior to 1916, practically all the production was by the compression process.
[b] Includes drip gasoline.

NATURAL GASOLINE PLANTS

According to the Oil and Gas Journal, Pennsylvania on May 1, 1932, had a total of 143 natural gasoline plants of which 130 were operating. At the time of the survey, only Oklahoma had more plants than Pennsylvania, and California had the same number.

However, the daily capacity of these plants presents a different aspect. Pennsylvania ranks eighth in the United States in the total

Biennial surveys of natural-gasoline plants in Pennsylvania

Year	Number of plants							Daily capacity (M. of gallons)						
				By processes							By processes			
	Operating	Shut-down	Total	Absorption	Compression	Combination	Charcoal	Operating	Shut-down	Total	Absorption	Compression	Combination	Charcoal
Jan. 1 1928[a]	138	15	153	20	121[c]	8	4	122	9	131	55	33[c]	31	12
Jan. 1 1930[a]	126	5	131	21	104[c]	4	2	122	6	128	70	33[c]	19	6
May, 1932[b]	130	13	143	23	116	2	2	109	10	119	74	28	11	6

[a] Data from Mineral Resources of the United States by U. S. Bureau of Mines.
[b] Data from Oil and Gas Journal, vol. 30, No. 53, May 19, 1932.
[c] Vacuum and gas pumps included under compression.

daily capacity of its plants. The majority of the natural gasoline plants in Pennsylvania have a small daily capacity, ranging from 5 gallons to 20,000 gallons a day with a total daily capacity of 118,947 gallons. To emphasize the difference in the size of plants, California which had the same number of raw gasoline plants had a total daily capacity of 4,014,430 gallons.

NATURAL-GAS GASOLINE PRODUCTION BY COUNTIES

In the following table, the production of casing-head gasoline is given by counties from 1913 to 1929. No statistics are available for 1922-1925.

For the years 1917-1919 and 1920, it will be observed that the production by counties is given for only the compression and vacuum pump method of manufacture. Counties in which this method was employed exclusively, have their production given as a whole. Counties in which the absorption process was used in addition to the compression process, have the production only by the latter method separated. Production by the absorption method is grouped for these various counties and is given in the Grouped Production column. In the table, all counties that have a claim on part of the grouped production figures for the year are footnoted and have plus (+) signs after their quantity and value figures.

Production and value of natural gas-gasoline by counties in Pennsylvania

(Units of thousands of gallons and thousands of dollars)

Year	Allegheny		Armstrong		Armstrong, Beaver and Lawrence		Beaver		Butler		Clarion	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1913 --	568	62	--------	-------	--------	-------	--------	-------	944	100	--------	-------
1914 --	530	39	--------	-------	--------	-------	--------	-------	1,022	75	--------	-------
1915 --	519	42	--------	-------	--------	-------	--------	-------	1,033	96	--------	-------
1916 --	693	125	--------	-------	--------	-------	27	35	1,278	219	--------	-------
1917 --	764+[e]	149+[e]	39+[e]	7+[e]	--------	-------	209	42	1,490+[e]	263+[e]	104+[e]	19+[e]
1918 --	726+[g]	136+[g]	162+[g]	32+[g]	--------	-------	213+[g]	45+[g]	1,450+[g]	261+[g]	381	77
1919 --	1,015	226	29+[j]	6+[j]	--------	-------	281+[j]	62+[j]	1,634+[j]	328+[j]	655	142
1920 --	1,318	263	55+[m]	12+[m]	--------	-------	260+[m]	47+[m]	1,578	300	858	181
1921 --	1,668	289	74	15	--------	-------	198	38	1,552	250	540	98
1926 --	2,273	301	--------	-------	195[p]	24[p]	--------	-------	672	85	563	74
1927 --	2,204	202	--------	-------	130[p]	13[p]	--------	-------	661	64	425	46
1928 --	1,912	183	--------	-------	316	30	--------	-------	493	45	427	43
1929 --	1,602	144	--------	-------	256	23	--------	-------	530	47	507	52

Year	Crawford		Elk		Elk and Potter		Forest		Greene		McKean	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1913	--------	------	--------	------	--------	------	256	30	--------	------	573	69
1914	--------	------	--------	------	--------	------	583	52	--------	------	986	78
1915	--------	------	--------	------	--------	------	544	55	--------	------	1,204	136
1916	--------	------	--------	------	--------	------	879	164	--------	------	1,780	316
1917	135	25	--------	------	--------	------	1,398+[e]	259+[e]	2,944	582	2,186+[e]	502+[e]
1918	258	43	606	135	--------	------	1,746	579	3,222	733	2,107+[g]	472+[g]
1919	368	67	356	88	--------	------	1,712+[j]	346+[j]	3,399	814	3,035	636
1920	877	136	393	87	--------	------	1,387	264	3,947	864	1,703+[m]	371+[m]
1921	727	98	384	67	--------	------	2,518	376	2,144	409	2,424	401
1926	274	30	--------	------	514[p]	50[p]	1,154	132	4,970	534	2,138	278
1927	439	37	--------	------	326[p]	31[p]	838	68	4,391	412	1,442	147
1928	164	15	--------	------	158	12	736	67	5,366	509	1,263	121
1929	191	18	--------	------	412	30	623	56	6,205	537	1,479	146

Year	Potter		Venango		Warren		Washington		Grouped Production	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1913	--------	------	266	24	838	92	--------	------	235[a]	27[a]
1914	--------	------	133	10	1,127	87	--------	------	231[b]	18[b]
1915	--------	------	--------	------	1,291	116	--------	------	1,308[c]	125[c]
1916	--------	------	325	61	1,514	287	88	16	140[d]	24[d]
1917	7+[e]	1+[c]	277+[e]	52+[e]	2,293+[e]	453+[e]	102+[e]	19+[e]	1,878[f]	405[f]
1918	264	58	238+[g]	45+[g]	2,268+[g]	485+[g]	113+[g]	17+[g]	2,024[h]	422[h]
1919	337	76	477+[j]	88+[j]	4,402	941	1,562	341	1,023[k]	247[k]
1920	306	67	752	348	2,856+[m]	579+[m]	1,766	401	2,094[n]	462[n]
1921	257	45	1,894	326	4,035	668	1,442	272	--------	------
1926	--------	------	3,026	393	2,667	330	1,897	223	--------	------
1927	--------	------	2,279	249	2,381	224	1,228	155	--------	------
1928	--------	------	2,677	248	2,026	190	1,033	107	--------	------
1929	--------	------	3,206	299	2,309	235	1,091	89	--------	------

[a] Grouped production and value of Washington, Potter, Greene and Crawford counties.

[b] Grouped production and value of Washington, Potter, Greene, Elk and Crawford counties.

[c] Grouped production and value of Washington, Venango, Crawford, Potter, Greene, Armstrong and Clarion counties.

[d] Grouped production and value of Potter, Clarion, Crawford, Armstrong and Greene counties.

[e] [g] [j] [m] Production and value of gasoline produced only by the compression and vacuum pump method. The plus sign indicates, for the county, some additional production and value which is given in the grouped counties column.

[f] Additional grouped production and value of gasoline produced by the absorption method in the counties under [e]. The entire production of Elk and Jefferson counties is included.

[h] Additional grouped production and value of gasoline produced by the absorption method in the counties under [g].

[k] Additional grouped production and value of gasoline produced by the absorption method in the counties under [j].

[n] Additional grouped production and value of gasoline produced by the absorption method in the counties under [m].

[p] Lawrence County included with Elk and Potter counties.

REVENUE FROM CRUDE OIL, NATURAL GAS AND NATURAL-GAS GASOLINE

The return from the sale of crude oil, natural gas and natural-gas gasoline in Pennsylvania up to January 1, 1929, amounted to $2,012,880,000 or a return of $12,361 per well drilled as shown in the following table.

During recent years, the revenue derived from natural gas and natural-gas gasoline has proportionately increased, being 46.1 per cent for natural gas and 2.9 per cent for natural-gas gasoline in 1928.

*Revenue derived from the sale of crude oil, natural gas and natural-gas gasoline in Pennsylvania 1859-1928 and 1928.**

Product	Period	Revenue derived				Return[1] per well drilled
		Period 1859-1928		Year 1928		
		Total	Per cent	Total	Per cent	
Crude oil	1859-1928	$1,272,930,000	60.5	$32,550,000	51.5	$7,479
Natural gas	1882-1928	793,545,000	37.7	29,114,000	46.0	4,663
Natural-gas gasoline	1911-1928	37,345,000	1.8	1,570,000	2.5	219
Total		$2,103,820,000	100.0	$63,234,000	100.0	$12,361

[1] Total number of wells drilled 1859-1928 inclusive, equals 170,190.
* Petroleum in the United States by Arnold and Kemnitzer.

ANNUAL AVERAGE PRICE

The table below shows the average annual price and the high and low price years of crude oil, natural gas and natural-gas gasoline during the period 1859 to 1928.

Mineral Resources volumes give the low annual average price of crude as $0.49 during 1861. Disregarding 1859 and 1860, the high annual average price of oil as given in Mineral Resources is $8.06 in 1864.

The following are the latest published annual average prices of: crude oil $2.61 a barrel (at well) in 1930; natural gas $0.290 per M. cubic feet (at well) in 1930; and natural-gas gasoline $0.091 per gallon (at plant) in 1929.

*Summary of annual average prices of crude oil, natural gas, and natural-gas gasoline in Pennsylvania, 1859-1928**

Product	Period		Annual Average Prices			
	Considered	Average	High (year)	Low (year)	1928	Unit
Crude oil	1859-1928	$1.579	$5.98 (1920)	$0.56 (1892)	$3.27	Barrel
Natural gas	1906-1928	0.185[a]	0.293 (1928)	0.134 (1906)[b]	0.293[c]	M. cu. ft.
Natural-gas gasoline	1911-1928	0.151	0.217 (1919)	0.075 (1911)	0.095	Gallon

[a] An average of prices at the point of consumption from 1906-1921 inclusive, and prices at the point of production from 1921 to 1928 inclusive.
[b] At the point of consumption.
[c] At the point of production.
* Petroleum in the United States by Arnold and Kemnitzer.

OIL ACREAGE

In the Special Report on Petroleum of the 10th U. S. Census Report (1880), the number of acres developed as oil acreage from August

26, 1859 to December 31, 1880, in the Pennsylvania oil fields is given by counties as follows:

Armstrong	5,120	Forest	1,920
Butler	27,520	McKean	50,000
Clarion	19,200	Venango	32,000
Crawford	6,400	Warren	6,720

The total oil land developed in Pennsylvania as given is 148,880 acres.

The 11th U. S. Census Report gives the land held as oil territory in Pennsylvania and New York on December 31, 1889 as follows (units of acres):

	Owned	*Leased*	*Total*
Bradford-Allegany	90,515	92,346	182,861
Forest	12,194	18,701	30,895
Warren	33,744	54,742	88,486
Butler-Clarion-Venango-Armstrong	142,634	208,644	351,278
Allegheny	3,407	29,564	31,971
Beaver and Smiths Ferry	981	27,831	28,812
Washington	2,544	109,593	112,137
Greene	275	41,808	42,083
Franklin	3,216	1,660	4,876
Totals	289,510	584,889	873,399

The Mineral Resources publications show statistics on oil acreage from 1909 to 1919 with the exception of 1911 and 1912 when the compilations were not completed. Figures for 1919 from the 14th U. S. Census Report do not separate the oil from the gas acreage and the combined total is shown in the gas acreage table.

*Acreage controlled by oil producers in Pennsylvania, by counties**

	Allegheny			Armstrong			Beaver		
Year	Fee	Lease	Total	Fee	Lease	Total	Fee	Lease	Total
1909	----------	----------	198,560	----------	----------	4,449	----------	----------	25,567
1910	4,689	37,206	41,895	547	2,828	3,375	2,219	23,109	25,328
1913	2,957	68,777	71,734	2,411	3,174	5,585	2,059	12,821	14,880
1914[a]	5,808	64,003	69,811	1,872	2,909	4,781	2.599	15,731	18,330
1915	3,667	63,433	67,100	1,943	2,164	4,107	1,480	16,171	17,651
1916	12,303	68,513	80,816	2,021	1,968	3,989	1,498	16,790	18,288
1917	4,035	86,122	90,157	1,405	2,684	4,089	839	16,045	16,884
1918	3,771	77.277	81,048	1,228	6,556	7,784	1,141	16,259	17.400

	Butler			Clarion			Crawford		
Year	Fee	Lease	Total	Fee	Lease	Total	Fee	Lease	Total
1909	----------	----------	93,690	----------	----------	52,565	----------	----------	4,104
1910	26,222	79,892	106,114	10,410	49,088	59,498	287	3,610	3,897
1913	21,229	59,626	80,855	11,768	21,414	33,182	983	4,909	5,892
1914[a]	29,099	67,664	96,763	13,293	52,431	65,724	4,597	1,009	5,606
1915	32,718	88,149	120,867	16,523	45,581	62,104	1,031	4,301	5,332
1916	25,101	74,015	99,116	16,063	43,852	59,915	1,040	3,633	4,673
1917	23,474	73,331	96,805	14,630	44,600	59,230	953	3,717	4,670
1918	23,512	67,236	90,748	10,039	70.507	80,546	849	3.592	4,441

Acreage controlled by oil producers in Pennsylvania, by counties (Cont'd)*

Year	Elk			Forest			Greene		
	Fee	Lease	Total	Fee	Lease	Total	Fee	Lease	Total
1909	--------	--------	90,322	--------	--------	78,293	--------	--------	160,304
1910	15,632	87,720	103,352	27,873	37,189	65,062	615	69,041	69,656
1913	12,169	55,433	67,602	36,864	40,988	77,852	1,327	78,494	79,821
1914[a]	32,940	57,534	90,474	40,839	27,104	67,943	846	78,115	78,961
1915	11,757	59,625	71,382	29,409	38,451	67,860	1,766	103,371	105,137
1916	27,577	61,425	89,002	40,072	30,009	70,081	756	111,460	112,216
1917	27,552	36,159	63,711	53,330	28,605	81,941	740	151,193	151,933
1918	30,894	69,594	100,488	43,111	33,971	77,082	590	147,831	148,421

Year	Jefferson			Lawrence			McKean		
	Fee	Lease	Total	Fee	Lease	Total	Fee	Lease	Total
1909	--------	--------	44,406	--------	--------	2,570	--------	--------	203,521
1910	5,782	39,679	45,461	0	2,200	2,200	66,976	11,151	178,127
1913	9,540	32,717	42,257	97	15,470	15,567	91,394	120,475	211,869
1914[a]	557	33,569	34,126	906	15,889	16,795	83,472	127,287	210,759
1915	522	39,994	40,516	239	14,669	14,908	73,579	115,830	189,409
1916	629	36,798	37,427	1,337	12,342	13,679	73,729	117,452	191,181
1917	882	38,092	38,974	1,339	11,262	12,601	77,410	114,989	192,399
1918	955	38,428	39,383	2,075	10,496	12,571	70,294	130,090	200,384

Year	Mercer			Potter			Tioga		
	Fee	Lease	Total	Fee	Lease	Total	Fee	Lease	Total
1909	--------	--------	3,578	--------	--------	56,841	--------	--------	685
1910	550	2,581	3,131	304	15,011	15,315	0	635	635
1913	230	2,995	3,225	36,337	8,861	45,198	0	247	247
1914[a]	234	2,033	2,267	256	87	343	0	367	367
1915	258	2,729	2,987	1,522	688	2,210	0	367	367
1916	478	6,522	7,000	1,286	722	2,008	0	367	367
1917	3,798	7,638	11,436	1,286	622	1,908	0	372	372
1918	3,758	6,771	10,529	1,286	622	1,908	80	120	200

Year	Venango			Warren			Washington		
	Fee	Lease	Total	Fee	Lease	Total	Fee	Lease	Total
1909	--------	--------	211,874	--------	--------	88,340	--------	--------	173,124
1910	45,170	87,866	133,036	20,803	44,133	64,936	1,309	102,841	104,150
1913	49,548	65,571	115,119	34,811	43,585	78,396	2,172	131,480	133,652
1914[a]	42,035	49,803	91,838	39,777	39,952	79,729	7,099	56,533	63,632
1915	65,342	71,917	137,259	36,733	53,054	89,787	4,096	85,525	89,621
1916	57,494	79,748	137,242	36,236	55,086	91,322	3,142	81,871	85,013
1917	60,337	77,076	137,413	34,944	47,846	82,790	3,755	116,507	120,282
1918	71,310	73,322	144,632	41,011	46,566	87,567	2,706	110,762	113,468

Year	Total		
	Fee	Lease	Total
1909	--------	--------	1,492,793
1910	229,388	797,546	1,026,934
1913	315,896	767,037	1,082,933
1914[a]	306,229	695,245	1,001,474
1915	282,585	806,019	1,088,604
1916	300,762	802,573	1,103,335
1917	310,850	857,309	1,168,159
1918	308,610	909,990	1,218,600

[a] In 1914, 3,000 acres were under lease in Bradford County and 225 acres under lease in Westmoreland County.

* Data from Mineral Resources of the United States by U. S. Geological Survey.

GAS ACREAGE

Statistics on the acreage controlled by natural gas operators were first compiled by the U. S. Geological Survey in 1906 and carried through to 1918. During 1919 the gas and oil acreage were not separated and are taken from the 14th U. S. Census Report. In 1921, the Bureau of Statistics of the Pennsylvania Department of Internal Affairs gives the leased acreage and continues these figures until 1931.

Acreage controlled by natural gas producers in Pennsylvania

Year	In fee	Leased	Gas rights	Total
1906	322,029	1,325,664		1,647,693
1907	334,454	1,419,808		1,754,262
1908	350,074	1,508,809		1,858,884
1909	116,315	1,509,462	220,299	1,846,076
1910	84,994	1,464,534	400,205	1,949,733
1911	103,595	1,372,131	557,046	2,032,772
1912	115,242	1,675,116	397,030	2,187,388
1913	146,472	1,684,925	380,043	2,211,440
1914	179,929	1,577,889	395,301	2,115,119
1915	178,419	1,619,993	375,991	2,174,403
1916	179,753	1,837,648	380,717	2,398,118
1917	169,039	1,927,058	339,932	2,436,029
1918	181,231	1,803,195	425,884	2,410,310
1919[a]	396,700	2,110,179		2,506,879
1920				
1921		1,928,491*		
1922		2,017,910*		
1923		2,375,342*		
1924		2,452,412*		
1925		2,651,419*		
1926		2,592,291*		
1927		2,653,079*		
1928		2,636,854*		
1929		2,777,199*		
1930		3,090,381*		
1931	441,549*	2,661,994*		3,103,543*

[a] Oil and gas acreage combined. Data from 14th Census, vol. XI.

* Data from Productive Industries by Pennsylvania Department of Internal Affairs.

LAND CLASSIFICATION AND RESERVES

In the following table, the area of Pennsylvania is divided into various classes of petroleum acreage. Three versions are given, the first being taken from a report to the American Petroleum Institute on American Petroleum, Supply and Demand, published in 1925. This report also presents the reserves of petroleum in Pennsylvania.

The second view on land classification is from office data of the Pennsylvania Geologic Survey and was compiled during December, 1925. The compilation was accomplished by the planimeter method on a map entitled, Oil and Gas Fields in Western Pennsylvania, published 1920. However, the compiler brought the material up to date (January, 1926) with information available in the office. The oil-producing area by counties as figured with the planimeter is as follows (acre units):

Oil acreage by counties

Allegheny	65,856	Forest	22,336	Venango	83,904
Armstrong	14,720	Greene	15,296	Warren	49,216
Beaver	18,624	Jefferson	512	Washington	55,104
Butler	144,704	Lawrence	14,528	Westmoreland	320
Clarion	27,328	McKean	94,400	New developments not on 1920 map (chiefly in Greene County)	9,600
Crawford	13,824	Mercer	11,648		
Elk	8,448	Potter	128		
Fayette	256	Tioga	640		
				Total	651,392

The third version is taken from Petroleum in the United States and its Possessions by Arnold and Kemnitzer. Oil and gas areas are combined in the figures from this source but where possible they are separated and given in the footnotes to the table.

Classification of petroleum acreage and reserves for Pennsylvania

(Units of acres and barrels.)

Reference	Dates of information	Total area	Producing area	Proved undeveloped area	Prospective oil area	Unfavorable areas
A	July, 1925	28,880,640[a]	380,000	11,000	10,706,640	17,783,000
B	Jan., 1926	28,692,480[b]	651,392	6,500[d]	7,693,300[e]	20,999,180
C	Jan., 1929	28,880,640[a]	1,820,160[c]	---------------	12,204,800	14,855,680[f]

Reference	Dates of information	Reserve of producing wells (flowing and pumping)	Oil recoverable in proved undeveloped area (flowing and pumping)	Reserves of producing and proved areas (flowing and pumping)	Estimated amt. of oil left in ground under producing and proven areas after flowing and pumping cease
A	July, 1925	80,000,000	6,000,000	86,000,000	520,000,000

A. Data from American Petroleum, Supply and Demand, Report to American Petroleum Institute.

B. Data by Pennsylvania Geological Survey. Producing and proved acreage figured by planimeter methods from the oil and gas pool map accompanying the report, Oil and Gas in Pennsylvania, by Ashley and Robinson.

C. Data from Petroleum in United States and Possessions by Arnold and Kemnitzer. Figures include oil and gas.

[a]. Includes water area.

[b]. Does not include water area.

[c]. Further subdivided to: oil area 869,120 acres; gas area 951,040 acres.

[d]. General estimate of undrilled inside acreage. Top estimate is not more than 13,028 acres.

[e]. Probably half of this area has been thoroughly tested by the drill without finding oil. Area given is defined by lines which enclose all of the points at which oil has been found.

[f]. Further subdivided to: impossible area 1,708,809 acres; unfavorable area 13,146,880 acres.

PETROLEUM PIPE LINE MILEAGE

The first oil pipe line was laid in 1861 and extended from Titusville four miles down Oil Creek. The line consisted of 4-inch cast iron pipe with leaded joints and leaked badly under the slight pressure to which it was subjected.

The next attempt to transport oil by pipe was in 1865, when the 2-inch tubing of the wells on the Miller farm were extended to Pithole, a distance of six miles. There were two intermediate pump stations on the line but these were later abandoned as unnecessary. The success of this line led to other operators using the pipe line method of transportation. According to Volume J of the Pennsylvania Second Geological Survey, in 1875 there were about 850 miles of trunk oil pipe lines in Pennsylvania and including the branches to the wells nearly 2,000 miles of pipe used for oil transportation.

Mineral Resources during 1924 and 1926 gathered statistics on the crude oil pipe-line mileage and capacity in Pennsylvania. The results are given in the following table:

*Petroleum pipe-line mileage and capacity in Pennsylvania**

Years	Trunk lines		Gathering lines		Total	
	Miles	Capacity (bbls.)	Miles	Capacity (bbls.)	Miles	Capacity (bbls.)
1924 (Spring)	5,274	1,100,600	6,094	201,300	11,368	1,301,900
1926 (May)	5,260	1,065,000	6,340	210,300	11,600	1,275,300

*Mineral Resources of the United States by U. S. Bureau of Mines.

STORAGE FACILITIES

The capacity and types of storage facilities for crude oil and refined products at tank farms and refineries in Pennsylvania during May, 1926, was as follows according to data from Mineral Resources by the U. S. Bureau of Mines:

A. Storage at refineries:
  a. For crude oil
    Steel .... 3,318,000 barrels
    Wood .... 32,000 "
  b. For refined products
    Steel .... 10,379,000 barrels
    Concrete . 4,000 "

B. Tank farm storage for crude oil:
    Steel .... 9,304,000 barrels
    Wood .... 121,000 "

C. Grand total of storage capacity for crude oil and refined products in Pennsylvania—23,158,000 barrels.

REFINERIES

The first crude oil refinery in the world was built in 1854 by M. S. Kier in Pittsburgh. The capacity did not exceed five barrels a day and the product was illuminating oil. The petroleum treated in the still came from salt water wells located at Tarentum.

In 1862, the first two refineries of importance in Pennsylvania were built. They were the Humboldt at Plumer, on Cherry Run, in Venango County, and the Downer at Corry, Erie County.

The Oil City Derrick gives the number of refineries in Pennsylvania in 1873 as 67 with a total daily capacity of 18,900 barrels.

According to the U. S. Bureau of Mines on January 1, 1920, there were 56 refineries in Pennsylvania with a total daily capacity of 102,175 barrels. At that time, two refineries were under construction and were to have a daily capacity of 1,000 barrels. On January 1, 1932, according to the same bureau, there were 48 refineries in Pennsylvania with a total daily capacity of 258,250 barrels of which 10,750 barrels represented refineries that were shut down. The following table shows the location, type and capacity of the refineries listed on

List of petroleum refineries and cracking plants in Pennsylvania, January 1, 1932

Company	Petroleum refineries				Cracking plants			
	Location	Daily capacity (barrels)	Type of [a] plant	Status [b]	Number units	Total daily charging capacity (bbls.)	Type of process	Status [b]
Atlantic Refining Co.	Franklin	9,000	Comp.	Op.	6	6,000	Cross	Op.
Atlantic Refining Co.	Philadelphia	50,000	Comp.	Op.	10	20,000	Cross	Op.
					4	10,000	de Florez	Op. } Phila.
					2	2,600	Lewis	Op.
Atlantic Refining Co.	Pittsburgh	8,000	Comp.	Op.	2	4,000	Cross	Op.
Bradford Oil Refining Co.	Bradford	1,500	S. & L.	Op.				
Canfield Oil Co.	Coraopolis	1,000	S. & L.	Op.				
Carnegie Refining Co.	Carnegie	1,000	Comp.	Op.				
Conewango Refining Co.	Langdale	2,450	Lube	SD.	2	500	Snodgrass	SD.
Conewango Refining Co.	Warren	1,700	Lube	Op.				
Continental Refining Co.	Oil City	1,000	Comp.	Op.				
Crew Levick Co.	Titusville	3,000	Comp.	Op.				
Crystal Oil Works	Rouseville	1,000	Comp.	Op.				
W. H. Daugherty & Son Refining Co.	Petrolia	2,000	S. & L.	Op.				
Franklin Creek Refining Corp.	Franklin	1,000	S. & L.	Op.				
Franklin Leasing Co.	Franklin	900	Comp.	SD.				
Freedom Oil Wor s Co.	Coraopolis				1	500	Dubbs	SD.
Freedom Oil Wor s Co.	Freedom	2,000	Comp.	Op.				
Gulf Refining Co.	Girard Point	32,000	S. & L.	Op.	7	19,000	Own	Op.
Gulf Refining Co.	Neville Island	7,500	Skim	Op.	1	3,000	Own	Op.
Kendall Refining Co.	Bradford	3,400	Comp.	Op.	3	2,400	Dubbs	Op.
A. D. Miller Sons Co.	Pittsburgh	1,000	S. & L.	Op.				
Mutual Refining Co. (Sherwood Pet.)	Warren	800	Comp.	Op.				
Oil Creek Refining Co.	Titusville	1,000	Comp.	Op.				
Pennerude Refining Co.	Kennerdell	400	S. & L.	SD.				
Pa. Oil Products Refining Co.	Eldred	5,000	Comp.	Op.	1	1,000	Snodgrass	SD.
Pennsylvania Refining Co.	Karns City	2,000	Comp.	Op.				
Pennsylvania Refining Co.	Titusville	700	S. & L.	Op.				
Pennzoil Co.	Rouseville & McClintock	8,000	Comp.	Op.	3	4,500	Dubbs	Op.
Pure Oil Co.	Marcus Hook	20,000	Comp.	Op.	4	8,000	Cross	Op.
Pure Oil Co.	Marcus Hook				3	4,000	Gyro	Op.
Pure Penn Refining Co.	Clarendon	350	S. & L.	Op.				
Quaker State Oil Refining Corp.	Emlenton	1,650	Comp.	Op.	1	750	Dubbs	Op.
Quaker State Oil Refining Corp.	Farmers Valley	2,000	Comp.	Op.				
Quaker State Oil Refining Corp.	Oil City	1,800	Comp.	Op.				
Sinclair Refining Co.	Marcus Hook	20,000	S. & L.	Op.	20	26,000	Isom	SD.
Sinclair Refining Co.	Marcus Hook				4	17,000	Sinclair type 600	Op.
Starlight Refining Co.	Karns City	300	Pet.	Op.				

Sun Oil Co.	Marcus Hook	45,000	Comp.	Op.	10	20,000[c]	Own	Op.
Superior Oil Works	Warren	500	Comp.	Op.				
Swan-Finch Refining Co.	Warren	1,000	Comp.	SD.				
Texas Co.	Marcus Hook	1,500	Asph.	Op.				
Tiona Refining Co.	Clarendon	1,000	Comp.	Op.				
Tio-Penn Refining Co.	Tiona	500	Skim.	SD.				
Ultra-Penn Refining Co.	Bruin	1,000	Comp.	Op.	4	1,200	Snodgrass	SD.
United Refining Co.	Warren	2,000	Comp.	Op.				
Valvoline Oil Co.	East Butler	3,000	Comp.	Op.				
Valvoline Oil Co.	Warren	1,000	Comp.	Op.				
Vapor Phase Oils (Inc.)	Conewango				4	1,000	Ormont	SD.
Viking Oil Corp.	Clarendon	1,500	Comp.	SD.				
Waverly Oil Works Co.	Coraopolis	4,000	Skim.	SD.	1	1,500	Cross	SD.
Waverly Oil Works Co.	Pittsburgh	1,000	Comp.	Op.	1	1,000	Cross	SD.
Wolverine-Empire Refining Co.	Reno	1,000	Comp.	Op.				
Wolverine-Empire Refining Co.	Tidioute	800	S. & L.	Op.				
Total		258,250			94	153,950		

[a] Type of plant and products commonly produced.

(Comp). Complete plant	(S. & L.) Skimming and lube	(Lube) Lube plant	(Skim.) Skimming plant	(Pet.) Pet. treating plant	(Asph.) Asphalt plant
Gasoline	Gasoline	Gas, oil and fuel oil	Gasoline		Distillates
Kerosene	Kerosene	Lubricating oils	Kerosene		Gas, oil and fuel oil
Gas, oil and fuel oil	Gas, oil and fuel oil		Gas, oil and fuel oil		Asphalt
Lubricating oils	Lubricating oils				
Wax, if present in the crude					

[b] Status

Op.—Operating January 1, 1932.

SD.—Shut down January 1, 1932.

[c] Estimated

Reference—Petroleum Refineries in United States January 1, 1932—U. S. Bureau of Mines I. C. 6641.
Survey of Cracking Plants in United States January 1, 1932—U. S. Bureau of Mines I. C. 6648.

January 1, 1932. The table also gives the type, capacity and status on the same date of the cracking plants situated in Pennsylvania.

On January 1, 1932, Pennsylvania's rank in the United States was fourth in the number of refineries, fifth in the total daily capacity of refineries, and fourth in the total daily charging capacity of the cracking plants.

ANALYSES OF NATURAL GAS AND PETROLEUM

By W. O. Hickok, 4th

INTRODUCTION

Natural gas, petroleum, and other related substances are essentially chemical compounds of carbon and hydrogen with minor percentages of foreign elements. All of these compounds of carbon and hydrogen are mixtures of a great many hydrocarbons which are classified into at least 18 series. Eight of these series have been found to exist in petroleum, but members of the paraffin, naphthene, olefine, and benzine series comprise by far the greatest part of petroleum. In most series the lower members are gases, the intermediate members liquids, and the higher members solids; a few series (benzine) have only liquid and solid members.

Because the Geological Survey gets requests for this sort of information, the writer has assembled in handy form all the analyses of Pennsylvania natural gas and petroleum he could find. Some of these are in publications not always easy of access, and some are heretofore unpublished.

NATURAL GAS

Natural gas is a mixture of hydrocarbons ordinarily composed of the lower members of the paraffin series with small amounts of gaseous olefines and naphthenes. It also contains small amounts of nitrogen, hydrogen sulphide, carbon dioxide, and in some cases helium. Methane is nearly always the predominating constituent, representing about 80 per cent by volume, while ethane is second with 10 to 20 per cent.

Natural gas is classified as either wet or dry according to its content of gasoline. Wet gas is commonly associated with oil in oil fields and is generally obtained from the same sand that yields the oil. Dry gas contains chiefly methane and is not often associated with oil-producing sands. The analyses on page 92 show the constituents of the two types of gas after the removal of gasoline from the wet gas.

ANALYSES OF NATURAL GAS

No.	County	Location		Source of analysis				Physical properties		Chemical composition						
		Pool	Sand	Depth Feet	Date	Publication	B. t. u. per cu. ft.	Sp. Gr. Air = 1	H_2 Per cent	N_2 Per cent	CO_2 Per cent	O_2 Per cent	Total paraffin Per cent	CH_4 Per cent	C_2H_6 etc. Per cent	Total Per cent
1	Allegheny --------	Creighton			1884	1		.592	--------	--------	3.6	--------	96.4	96.4	--------	100
2	Allegheny --------	Pittsburgh			1894	3		--------	--------	.7	.4	--------	98.9	98.9	--------	100
3	Allegheny --------	Pittsburgh			1894	3		--------	--------	7.3	.5	--------	92.2	92.2	--------	100
4	Allegheny --------	Pittsburgh			1894	3		--------	--------	7.1	.3	--------	92.6	92.6	--------	100
5	Allegheny --------	a. (Wilkinsburg Sta.)			1931	7	1106	.61	--------	1	--------	--------	99.9	86.5	13.4	100
6	Allegheny and Washington --	a. (Walkers Mill pipe line)			1913	3	1241	.66	--------	1.6	--------	trace	98.4	74.1	24.3	100
7	Allegheny and Washington --	a. (Candor pipe line)			1913	3	1184	.64	--------	1.4	--------	.5	98.1	80.7	17.4	100
8	Allegheny and Washington --	a. (Imperial 10-inch line)			1913	3	1239	.66	--------	1.1	--------	.2	98.7	75.1	23.6	100
9	Armstrong --------				1884	1		.56	4.8	--------	.6	--------	94.6	89.7	4.9	100
10	Armstrong --------		Fourth		1911	4	1184	.64	--------	1.5	--------	--------	98.5	81.6	16.9	100
11	Beaver --------		Hundred-foot	1200	1887	2		--------	--------	9.9	--------	--------	90.1	--------	--------	100
12	Beaver --------		Hundred-foot	1400	1887	2		--------	--------	12.3	.4	--------	87.3	--------	--------	100
13	Butler --------				1883	1		.62	6.1	--------	.3	--------	93.6	75.5	18.1	100
14	Butler --------				1884	1		.51	13.5	--------	.7	--------	85.8	80.1	5.7	100
15	Butler --------		Speechley		1911	4	1420	.78	--------	.9	--------	--------	99.1	53.3	45.8	100
16	Butler --------	a. (Sarvier Sta.)			1931	7	1050	.59	--------	--------	.1	--------	99.9	93.2	6.7	100
17	Clarion --------		Fourth	800	1911	4	1703	.57	--------	1.1	--------	--------	98.9	96.4	2.5	100
18	Clarion --------		Bradford	2100	1911	4	1189	.65	--------	1.7	--------	--------	98.3	80.5	17.8	100
20	Clarion --------				1914	5	1302	.71	--------	1.1	--------	--------	98.9	67.6	31.3	100
19	Clarion --------	a. (Pew Sta.)			1931	7	1135	.64	--------	.1	.1	.1	99.7	82.9	16.8	100
21	Crawford --------				1910	4	927	60	--------	12.5	--------	--------	87.5	87.5	--------	100
22	Crawford --------				1911	4	1765	.99	--------	2.3	--------	--------	97.7	6.9	90.8	100
23	Elk --------				1916	6	1146	.61	--------	.8	--------	--------	99.2	88.0	11.2	100
24	Forest --------		Third		1911	4	1279	.70	--------	1.0	--------	--------	99.0	70.8	28.2	100
25	Greene --------					3	1222	.74	--------	2.9	--------	.2	96.9	73.1	23.8	100
26	Greene --------	a. (Brave Sta.)			1932	7	1136	.65	--------	.7	--------	.2	99.1	81.9	17.2	100
27	Greene --------	Gump	Big Injun	1935	1932	8	1073	.61	--------	1.1	--------	--------	98.9	89.5	9.4	100
28	Greene --------	Waynesburg	Gordon	2877	1932	8	1157	.67	--------	1.8	.1	--------	98.1	76.9	21.2	100
29	Greene --------	Richhill	Fifth	2960	1932	8	1118	.63	--------	.5	.1	--------	99.4	84.8	14.6	100
30	Greene --------	Gump	Bayard	3045	1932	8	1095	.61	--------	--------	--------	--------	100.0	89.2	10.8	100
31	Indiana --------				1884	1		--------	22.5	.8	2.3	7.3	67.1	60.3	6.8	100
32	McKean --------	E. Kane	Fourth		1887	2		--------	--------	9.4	.2	--------	90.4	--------	--------	100
33	McKean --------	W. Kane	Fourth		1887	2		--------	--------	9.8	.2	--------	90.0	--------	--------	100
34	Mercer --------				1916	6	1591	.89	--------	.7	--------	--------	99.3	32.3	67.0	100
35	Venango --------		Speechley	1900	1887	2		--------	--------	4.5	.1	--------	95.4	--------	--------	100
36	Venango --------				1916	6	1306	.74	--------	3.3	--------	--------	97.7	64.3	33.4	100

37	Warren		Fourth	1400	1886	2		-------	-------	9.1	.3	-------	90.6	-------	-------	100
38	Washington		(Several)		1887	2		-------	-------	15.3	.4	-------	84.3	-------	-------	100
39	Washington	Houston			1912	3	1155	-------	-------	9.1	1.0	-------	89.9	65.1	24.8	100
40	Washington	Gary deep well			1912	3	946	-------	-------	.8	3.6	.8	88.8	88.8	-------	100
41	Washington	[a]. (Peoples N. G. Co. pipe line)			1913	3	1199	.67	-------	.7	-------	-------	99.3	81.6	17.7	100
42	Washington	McDonald			1913	3	1719	1.01	-------	1.0	.2	-------	98.8	2.7	96.1	100
43	Washington	McDonald			1913	3	2185	1.59	-------	23.0	2.1	-------	74.9	-------	74.9	100
44	Washington	McDonald			1913	3	1204	-------	-------	.6	.1	30.1*	69.2	1.9	67.3	100
45	Washington	McDonald			1913	3	1561	-------	-------	16.5	1.5	28.5*	53.5	-------	53.5	100
46	Washington	Same well as 39			1914	3	1147	-------	-------	3.4	-------	-------	96.6	81.9	14.7	100
47	Westmoreland	Leechburg			1875	3		.56	4.8	-------	.4	.3†	94.5	89.6	4.9	100
48	Westmoreland	Grapeville			1886	3		-------	7.0	27.9	8	.1	64.2	36.1	28.1	100
49	Westmoreland	Lions Run	Murrysville		1887	2		-------	-------	2.0	.3	-------	97.7	-------	-------	100
50	Westmoreland				1897	3		-------	-------	4 4	.2	-------	95.4	95.4	-------	100

* Calculated as air.

† Contains CO.

a. Sample was collected from a pipe line or pumping station and so represents a number of sands from one or more pools.

1. Report L, Second Pennsylvania Geological Survey, pp. 146-160, analyst S. P. Sadtler, Harrisburg, 1876. Analysis by a poor method which shows hydrogen more abundant than is the case. The specific gravity is also in error.

2. Annual Report 1886, pt. 4, Second Pennsylvania Geological Survey, pp. 787-817, analyst F. C. Phillips, Harrisburg. 1887. Samples appear to have been diluted by air.

3. Mineral Resources of the United States, 1913, part II, pp. 1470-1471. Washington, 1914.

4. The condensation of gasoline from natural gas. Burrell, G. A., Seibert, F. M., and Oberfell, G. G. U. S. Bureau of Mines Bull. 88, pp. 21-22. Washington, 1915.

5. Composition of natural gas used in 25 cities. Burrell, G. A., and Oberfell, G. G. U. S. Bureau of Mines Technical Paper 109. Washington, 1915.

6. Analyses of natural gas from 31 cities in the United States. Burrell, G. A., and Robertson, I. W. U. S. Bureau of Mines Technical Paper 158. Washington, 1917.

7. Courtesy of J. French Robinson, Peoples Natural Gas Company.

8. Courtesy of S. W. Meals, Carnegie Natural Gas Company.

Analyses of wet and dry natural gas

(By United Natural Gas Company)

	1	2
Methane	84.35	64.96
Ethane	13.96	30.61
Propane	.55	1.70
Butane	.45	1.10
Pentane	.20	.73
Hexane and higher	.09	.40
Nitrogen	.40	.50
	100.00	100.00
Specific gravity (air = 1)	.640	.759
B. t. u. per cubic foot	1115	1299

1. Dry gas from Lewis Run measuring station. The gas is collected from sands in Jefferson, Elk, and southern McKean counties which do not produce oil.

2. Wet gas from Strong compressing station. The gas is collected from the Speechley sand in Venango County which is also producing oil.

As a general rule the value of natural gas lies in its heating ability in B. t. u. per cubic foot. Natural gas ranks highest of all gaseous fuels in this respect as can be seen from the following table.

Heat values of gaseous fuels

	B. t. u. per cu. ft.
Natural gas (wet)	1299
Natural gas (dry)	1115
Coal gas	634*
Coke oven gas	600-536*
Carburetted water gas	578*
Water or blue gas	310*
Producer gas	136*
Blast furnace gas	93

*Figures from Haslam, R. T., and Russell, R. P.; Fuels and their combustion: p. 282, 1926.

Helium has been found in natural gas from nearly every part of the world. It occurs in commercial quantity, however, only in the mid-continent oil fields. Traces of it have been found in some of the Pennsylvania natural gas but so rare as to be of scientific interest rather than of commercial value.

The composition and fuel value of natural gas from some of the pools and districts of Pennsylvania are shown in the table on pages 90 and 91.

PETROLEUM

Petroleum or crude oil is essentially a mixture of the intermediate and higher members of the paraffin and naphthene series of hydrocarbons although it contains slight amounts of the benzine and olefine series. Small amounts of nitrogen, oxygen, and sulphur also may be present either as organic acids or mechanically absorbed.

Crude oil is usually classified according to its so-called base, as for example paraffin, intermediate, hybrid, and naphthene base crude oils. Hybrid and naphthene base crude oils correspond to what has commonly been referred to in the industry as asphaltic base crude and intermediate as mixed base crude. The classification is based upon the nature of the substances recovered from the residuum remaining after distillation of the crude oil. If a large amount of the higher members of the paraffin series can be separated from the residuum the oil is classified as a paraffin base crude oil. If the higher members of the naphthene series compose most of the residuum, the oil is called naphthene base crude. Two intermediate types are also recognized; one which is similar to paraffin base oil but which contains members of the naphthene series and has some asphalt in the residuum is called intermediate base crude oil, and the other which is similar to naphthene base oil but contains some paraffin in the residuum is called hybrid base crude oil.

Pennsylvania crude oil is a paraffin base oil that is highly prized as a source of high grade lubricants. The lubricants made from Pennsylvania oil are superior to others because the crude oil from which they are made contains a greater ratio of the higher paraffin hydrocarbons to the higher naphthene compounds than most other crudes. The flash and ignition points of a paraffin lubricant are much higher than those of a naphthene or intermediate lubricant which has the same viscosity and so paraffin lubricant will last much longer under the stress of high temperatures in an internal combustion or other engine where the lubricant is subjected to high temperatures. The carbon residue from a paraffin lubricant is also much smaller than from an intermediate or naphthene lubricant, which is also advantageous for internal combustion engines.

The high "anti-knock" quality of some gasolines which is greatly prized, is not found in gasoline distilled from Pennsylvania crude oil. The "anti-knock" quality is given to gasoline by the presence of the cyclic naphthene hydrocarbons which slow up and equalize the rate of explosion. These cyclic hydrocarbons are found in the heavy naphthene and hybrid base oils and are also produced during the "cracking" of heavier oils to form gasoline.

Details of the composition of the crude oil from various pools and counties of Pennsylvania are given in the following table. Selected analyses from some of the important oil fields and districts outside of Pennsylvania are added for comparison.

The analyses correspond to the standard set up by the U. S. Bureau of Mines, and the summary of fractionation conforms with their arbitrarily determined standard which they summarize as follows (6, p. 6):

"The total percentage of all fractions distilling at atmospheric pressure below 200°C. (392°F.) is reported as total percentage of gasoline and naphtha if no fraction in this range has a gravity heavier than 40 A.P.I. This figure approximates the yield of gasoline and naphtha with a maximum boiling point of 215°C. (419°F.). If fractions boiling below 200°C. have gravities below 40° A.P.I. they are classed as gas oil.

"The total percentage of all fractions distilling at atmospheric pressure above 200°C. (392°F.) but below 275°C. (527°F.) that have gravities of 40 A.P.I. or lighter is reported as kerosene distillate.

"The total percentage of all fractions distilling at atmospheric pressure below 275°C. (527°F.) that have gravities heavier than 40 A.P.I. plus the vacuum distillate with a viscosity less than 50 seconds (Saybolt Universal at 100°F.) is reported as gas oil."

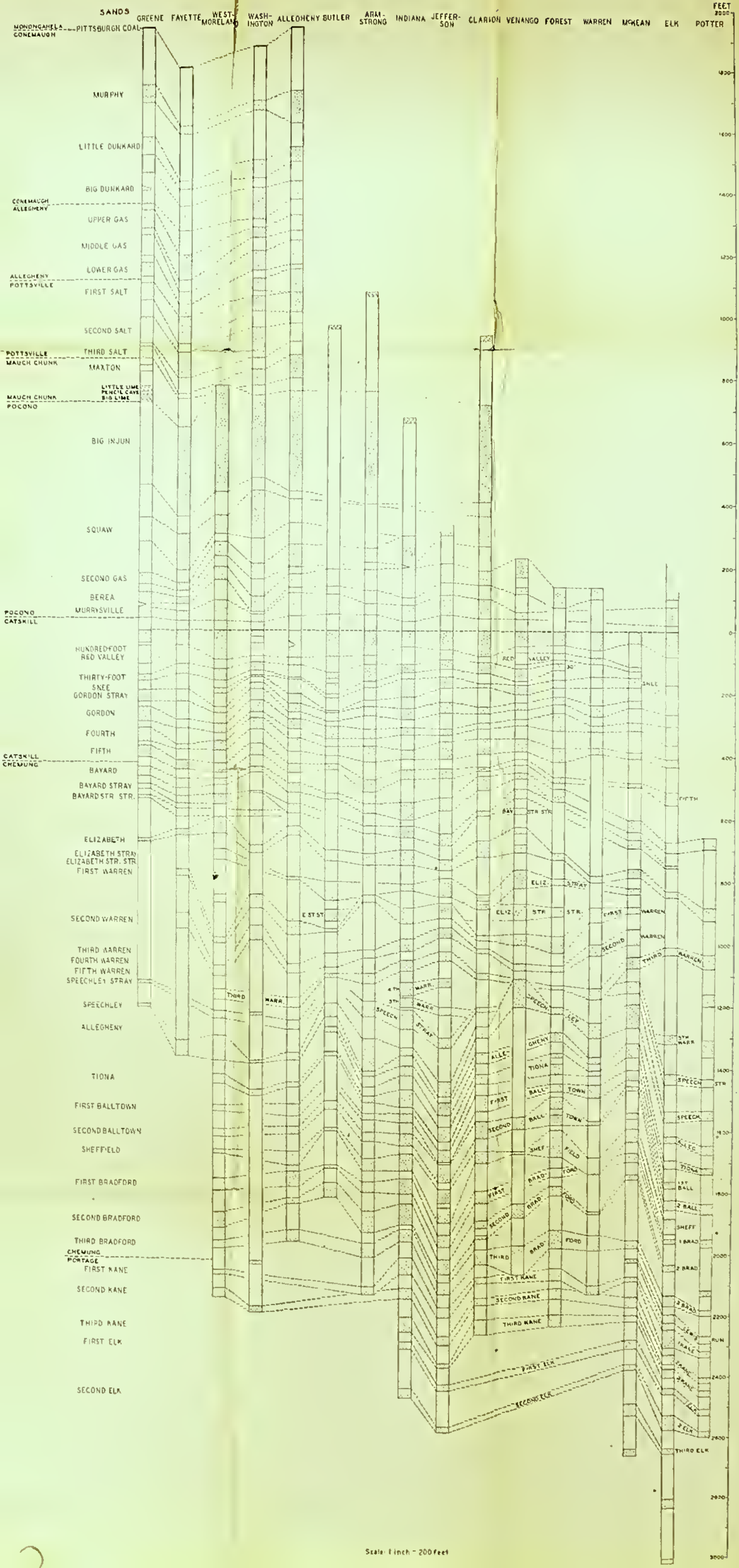
Lubrication distillates (vacuum distillated) are classified by the Saybolt Universal method as follows:

	Viscosity 100°F.
Nonviscous lubricating distillates	50—100
Medium lubricating distillates	100—200
Viscous lubricating distillates	Over 200

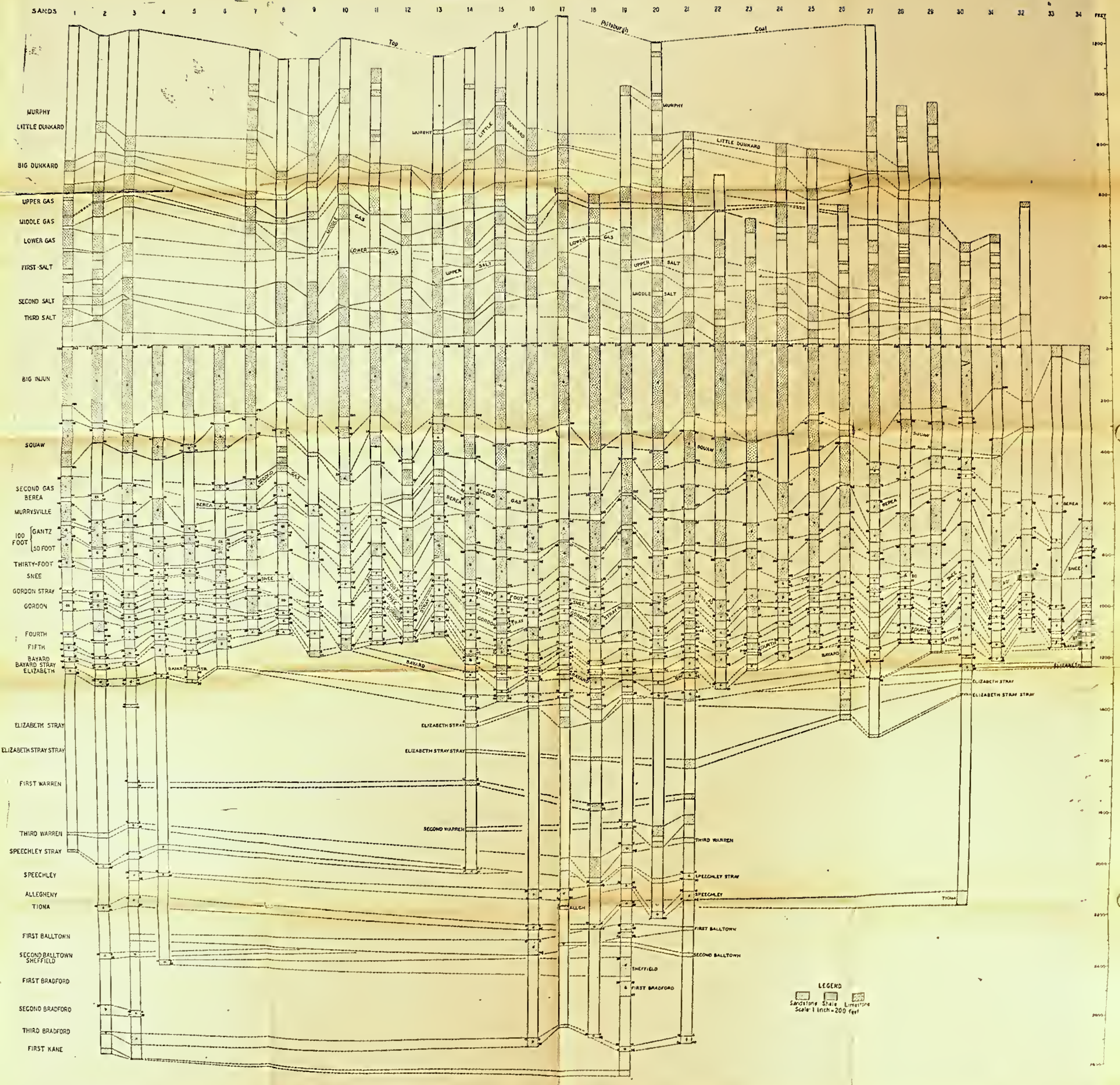
Bibliography on the composition and character of petroleum

1. Day, D. T., Handbook of the peroleum industry: pp. 467-586, 1922.
2. Clarke, F. W., Data of geochemistry: U. S. Geol. Survey Bull. 770, pp. 731-755, 1924.
3. Phelps, R. W., and Lake, F. W., Petroleum engineering: pp. 47-52, 1927.
4. Cross, Roy, Handbook of petroleum, asphalt, and natural gas: pp. 200-255 and 543-711, 1928.
5. Lilley, E. R., The geology of petroleum and natural gas; chapter II, pp. 15-35, 1928.
6. Smith, N. A. C., and Lane, E. C., Tabulated analyses of representative crude petroleums of the United States: U. S. Bur. Mines Bull. 291, 1928.

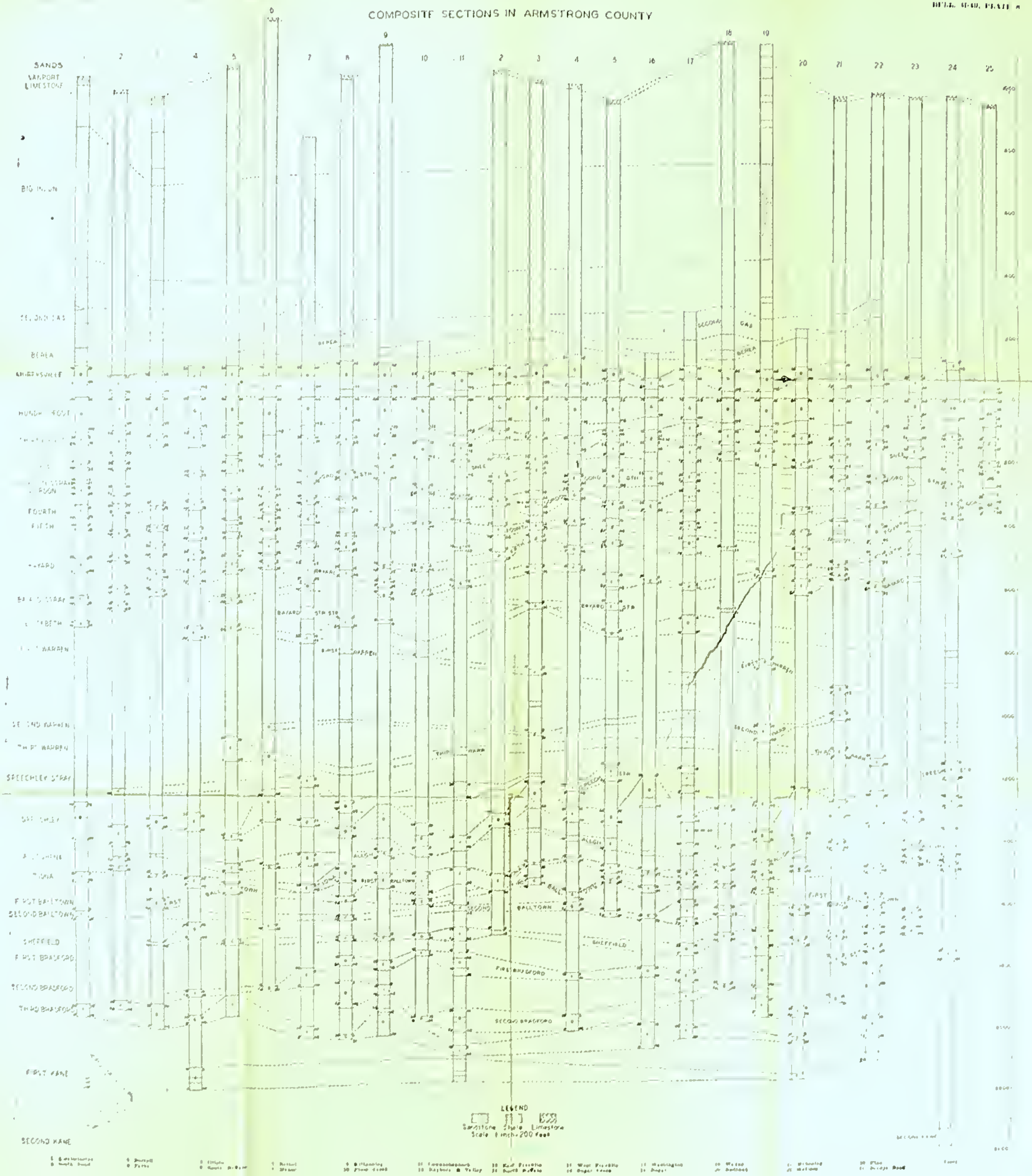
COMPOSITE SECTIONS



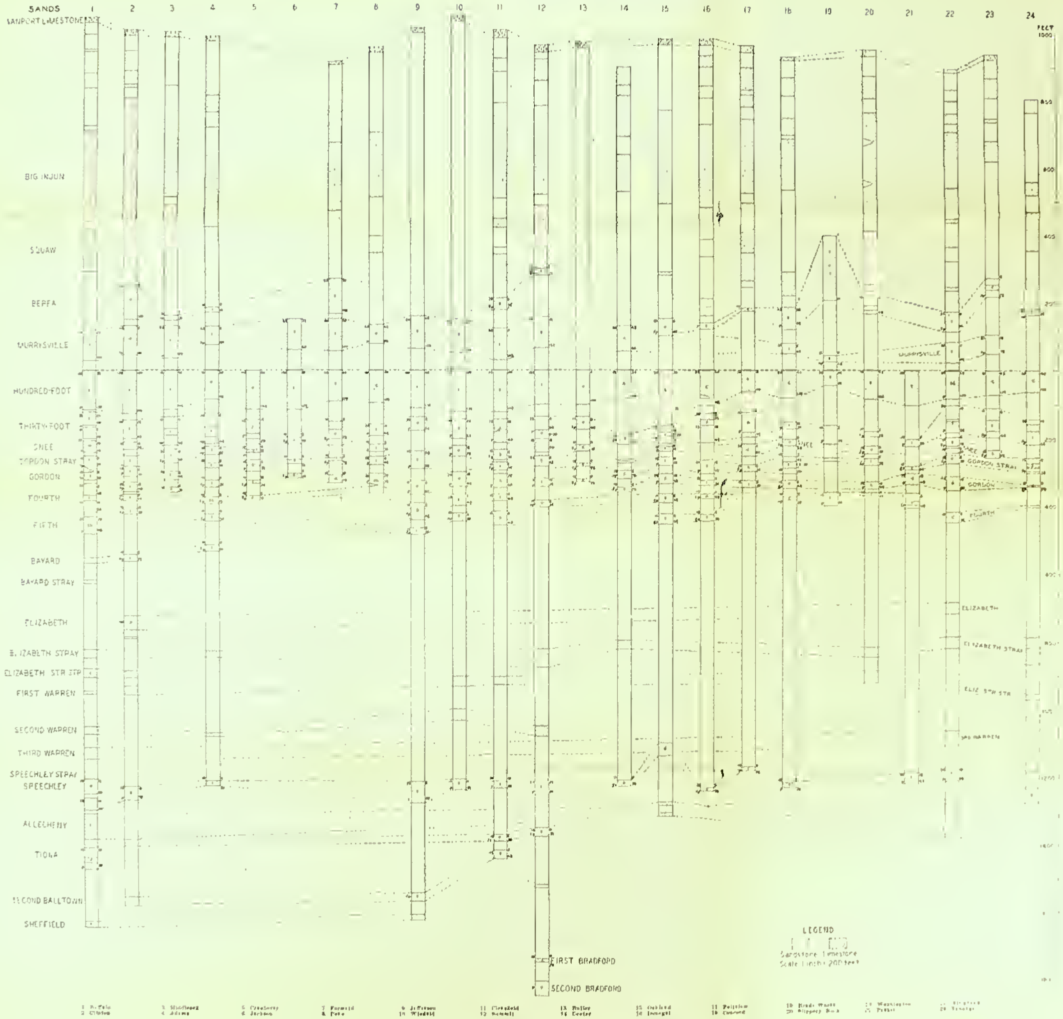
COMPOSITE SECTIONS IN ALLEGHENY COUNTY



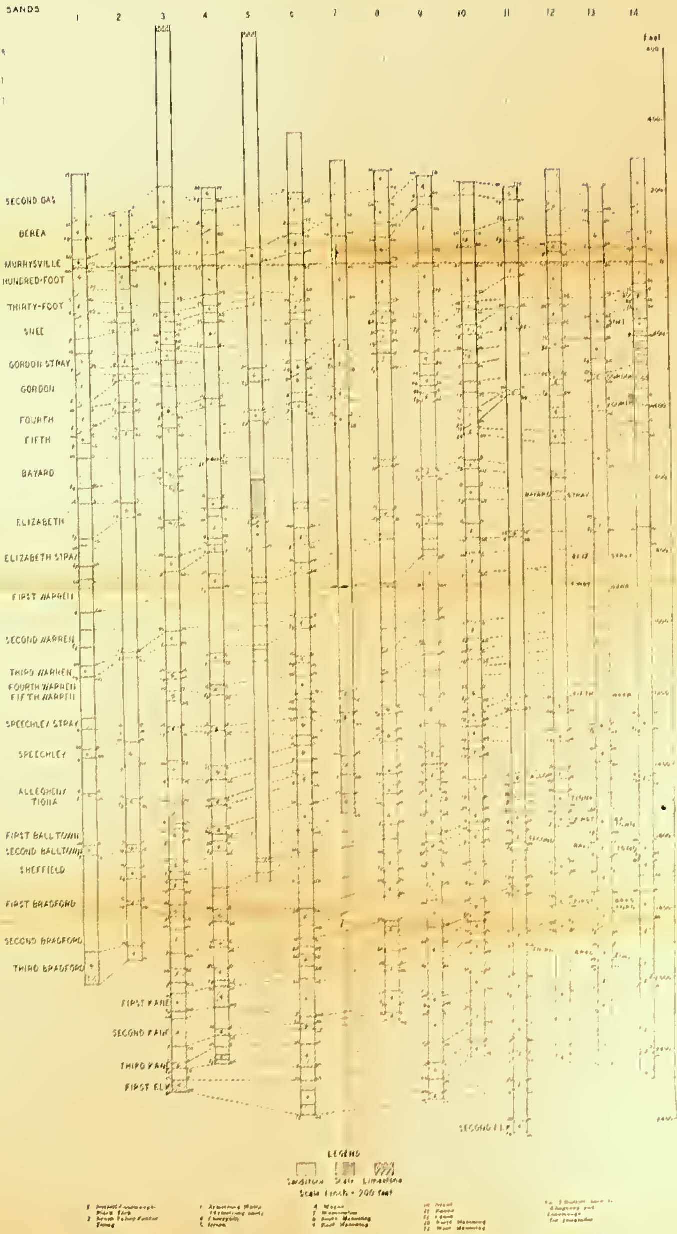
COMPOSITE SECTIONS IN ARMSTRONG COUNTY



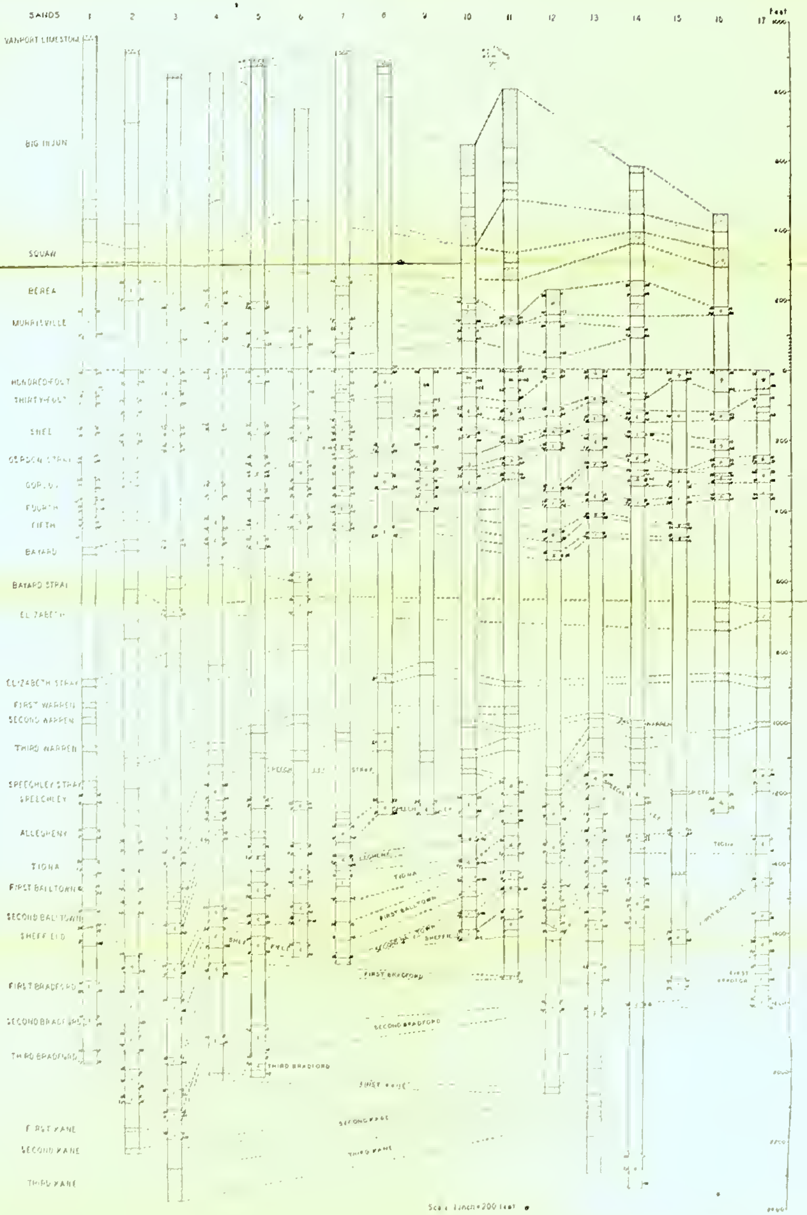
COMPOSITE SECTIONS IN BUTLER COUNTY



COMPOSITE SECTIONS IN INDIANA COUNTY

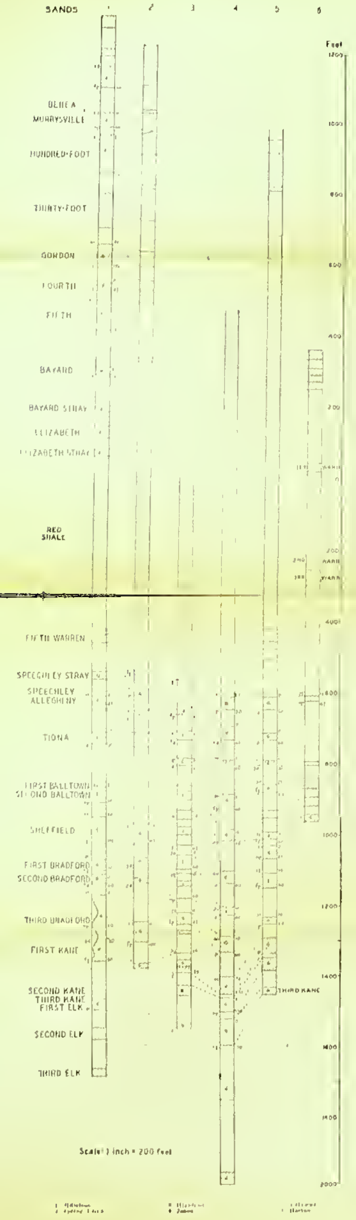


COMPOSITE SECTIONS IN CLARION COUNTY

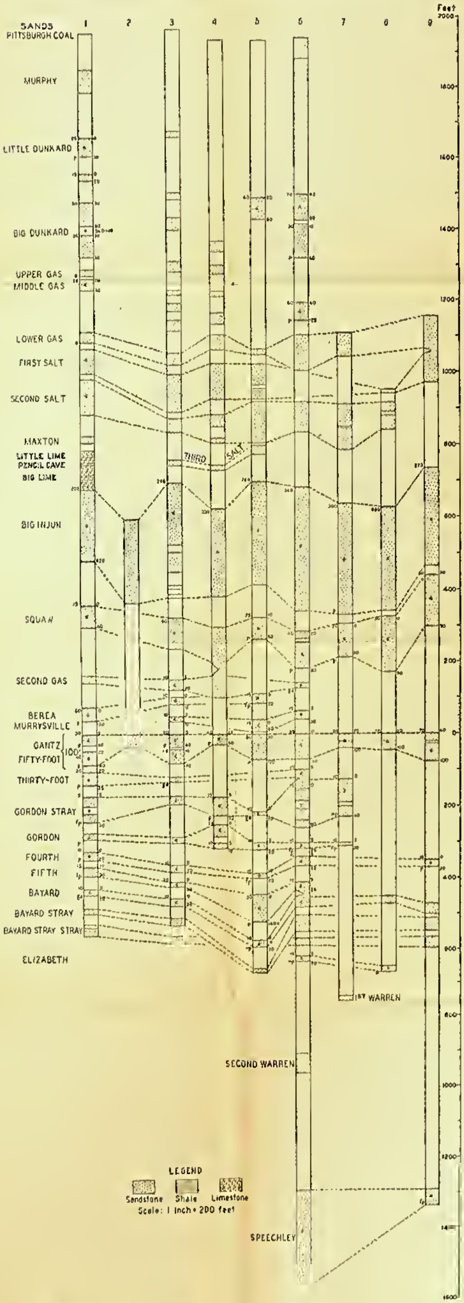


Scale 1 inch = 200 feet

COMPOSITE SECTIONS IN ELK COUNTY

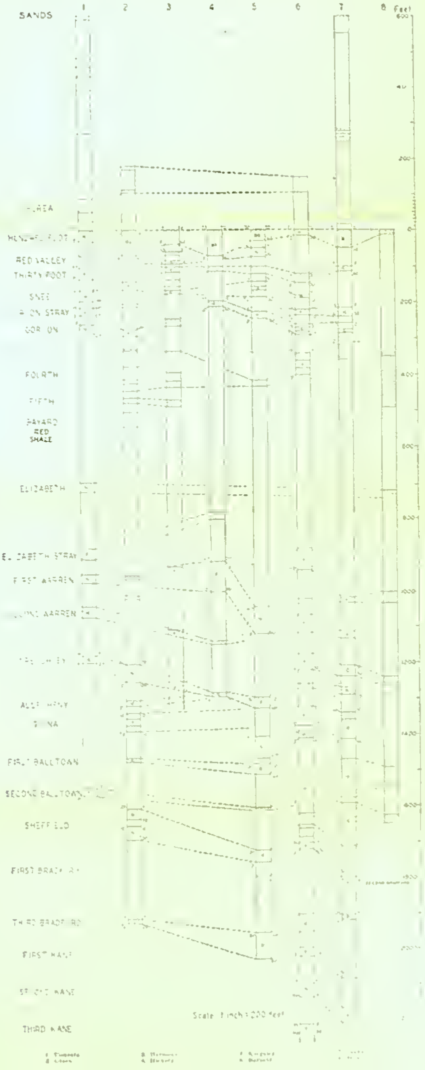


COMPOSITE SECTIONS IN FAYETTE COUNTY



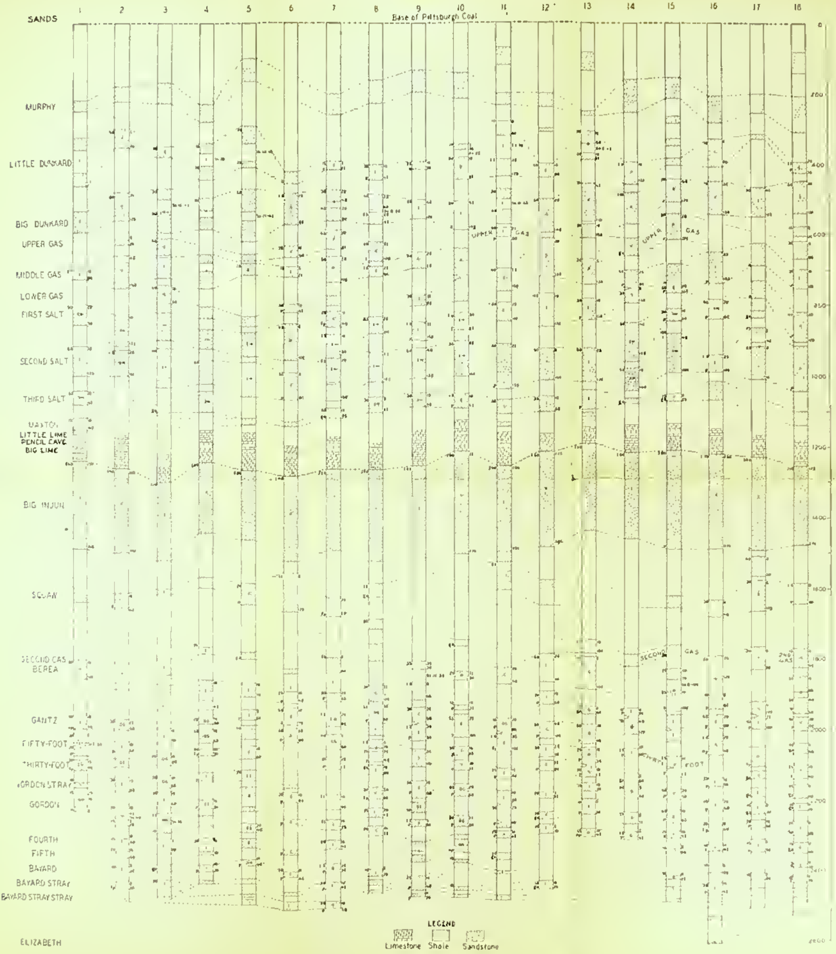
1 Springhill (well at [illegible] in Greene County)
2 Nicholson
3 Georges
4 Menallen
5 Redstone & Luzerne (Luzerne well)
6 Washington
7 Perry
8 Lower Tyrone
9 Franklin

COMPOSITE SECTIONS IN FOREST COUNTY



Scale 1 inch = 200 feet

COMPOSITE SECTIONS IN GREENE COUNTY



1 Springhill
2 Gilmore

3 Wayne
4 Perry

5 Dunkard
6 Monongahela

7 Greene
8 Whiteley

9 Franklin
10 Center

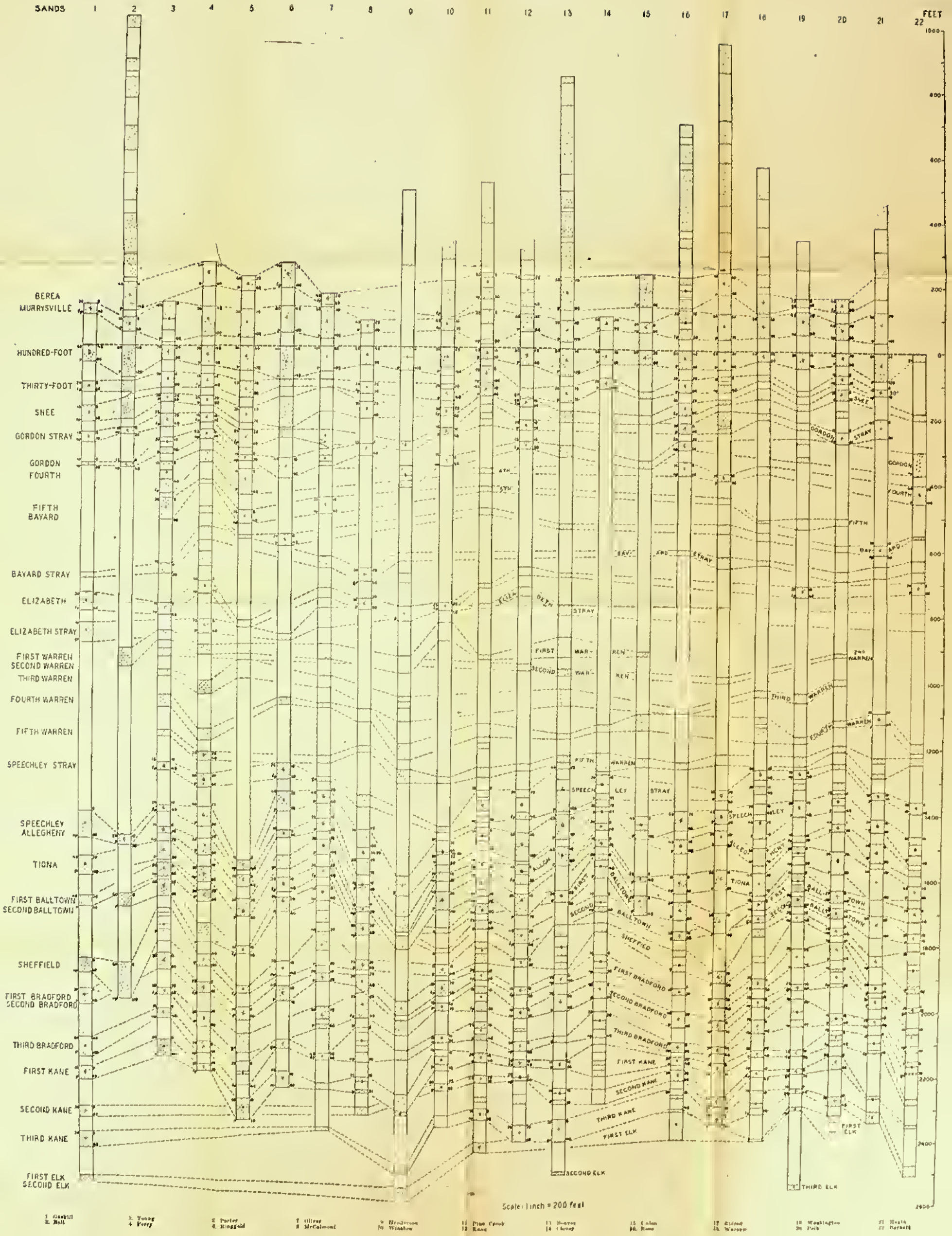
11 Jackson
12 Aleppo

13 Richhill
14 Morris

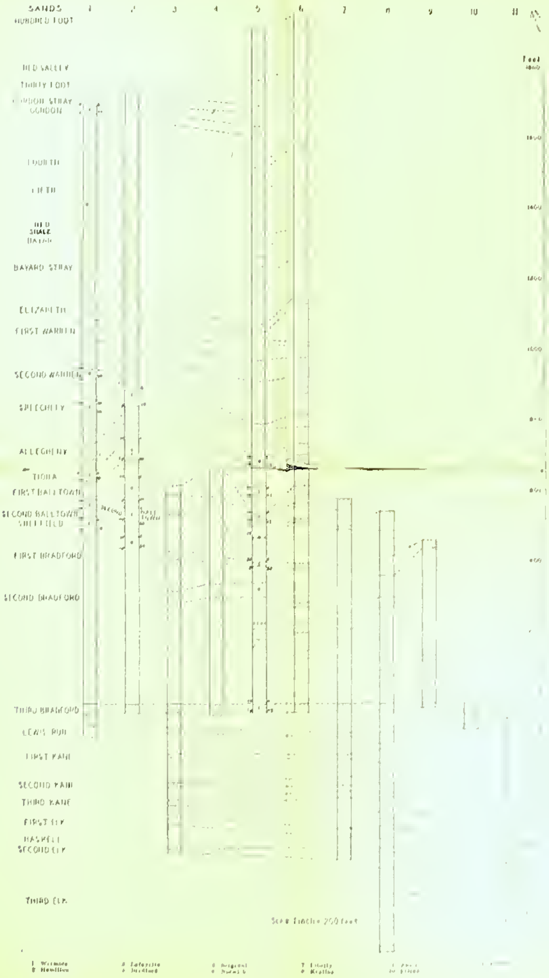
15 Washington
16 Morgan

17 Jefferson
18 Cumberland

COMPOSITE SECTIONS IN JEFFERSON COUNTY

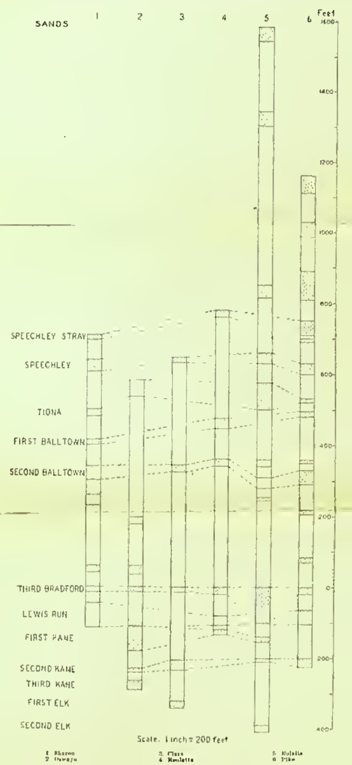


COMPOSITE SECTIONS IN McKEAN COUNTY



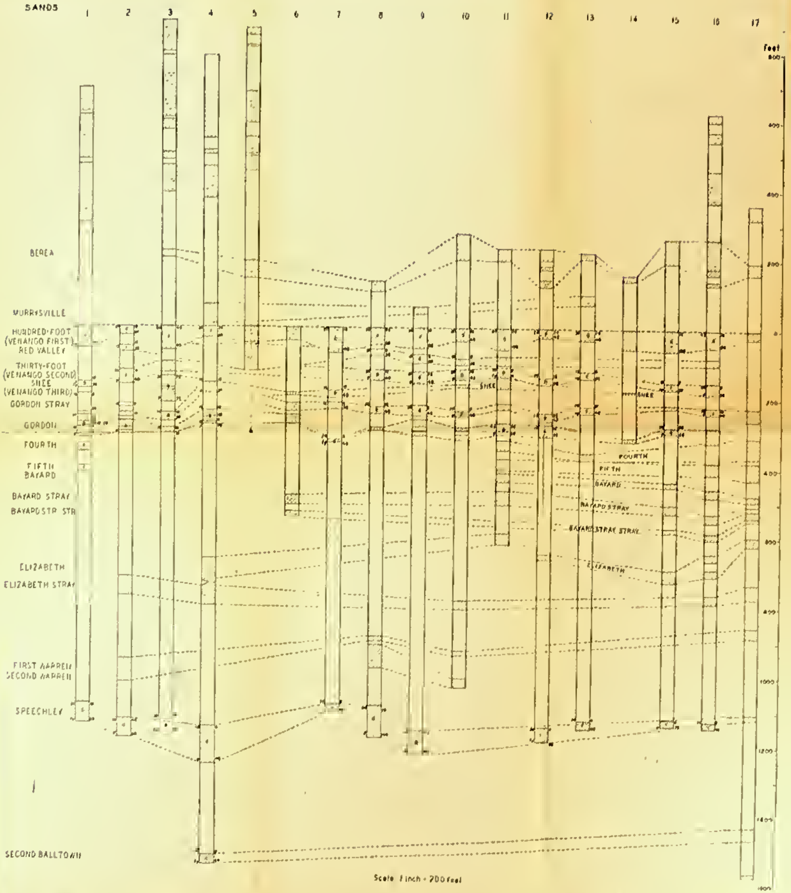
PENNSYLVANIA TOPOGRAPHIC AND GEOLOGIC SURVEY
BULL. M-19, PLATE 18

COMPOSITE SECTIONS IN POTTER COUNTY



PENNSYLVANIA TOPOGRAPHIC AND GEOLOGIC SURVEY [illegible] PLATE 10

COMPOSITE SECTIONS IN VENANGO COUNTY

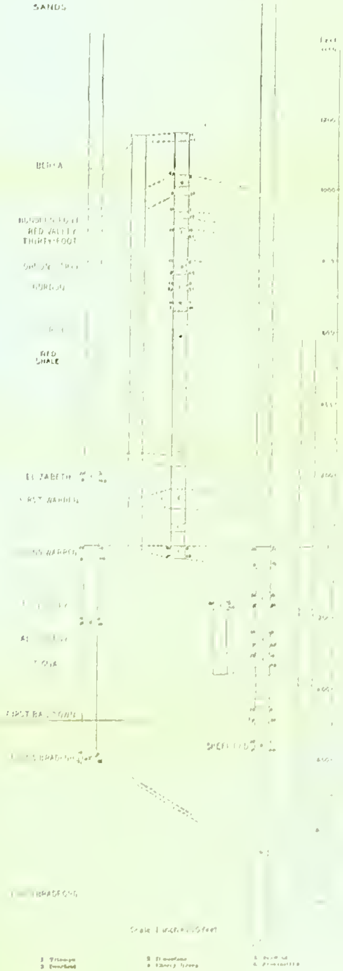


Scale 1 inch = 200 feet

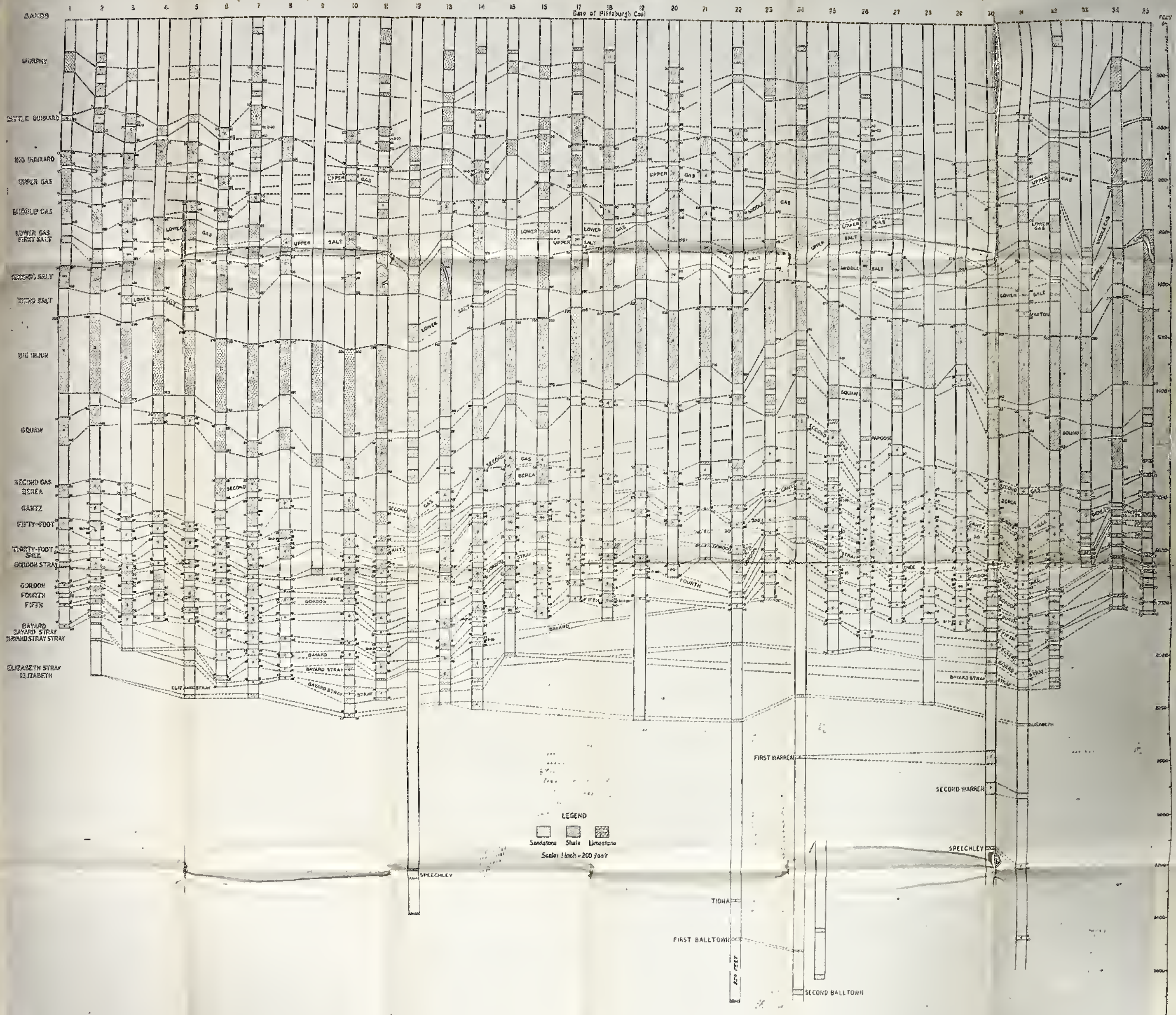
1 Richland
2 Rockland
3 Scrubgrass
4 Clinton
5 Irwin
6 Mineral
7 Victory
8 Cranberry
9 Pine Grove
10 President
11 Cornplanter
12 Sugar Creek
13 Jackson
14 Oakland
15 Cherry Tree
16 Oil Creek

PENNSYLVANIA TOPOGRAPHIC AND GEOLOGIC SURVEY
BULL. M10 PLATE 20

COMPOSITE SECTIONS IN WARREN COUNTY

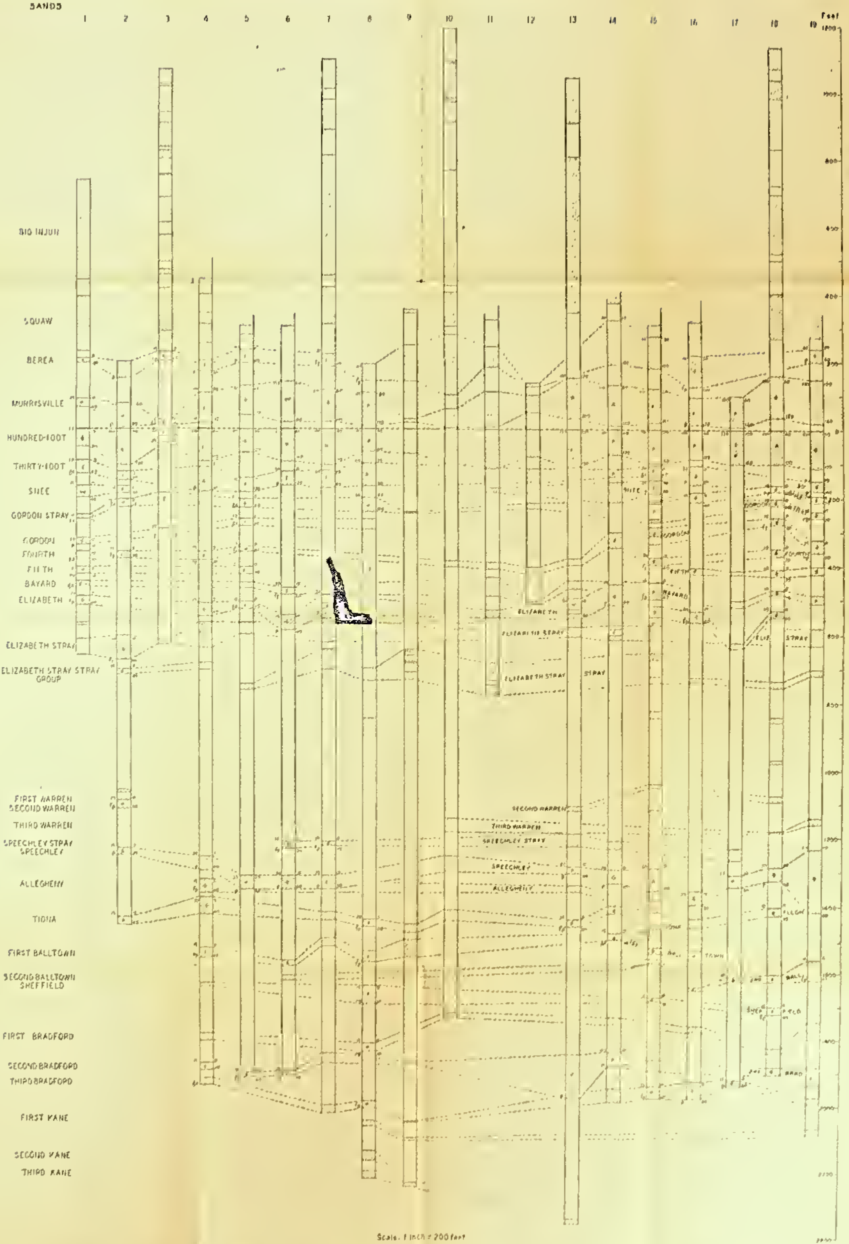


COMPOSITE SECTIONS IN WASHINGTON COUNTY



1 West Finley
2 East Finley
3 Morris
4 South Franklin
5 Amwell
6 West Bethlehem
7 Deemston
8 East Bethlehem
9 Centerville Boro
10 East Pike Run
11 West Pike Run
12 Allen
13 Fallowfield
14 Somerset
15 South Strabane
16 North Franklin
17 Canton
18 Buffalo
19 Blaine
20 Donegal
21 Independence
22 Hopewell
23 Jefferson
24 Cross Creek
25 Mt Pleasant
26 Chartiers
27 Cecil
28 North Strabane
29 Peters
30 Nottingham
31 Union
32 Carroll
33 [illegible]
34 Smith
35 Robinson

COMPOSITE SECTIONS IN WESTMORELAND COUNTY



Scale, 1 inch = 200 feet